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The Dock & Harbour Authority

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FEB 02 1963

No. 387. Vol. XXXIII.

JANUARY, 1953.

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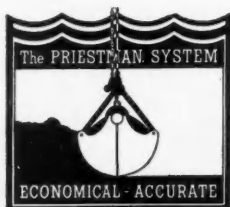
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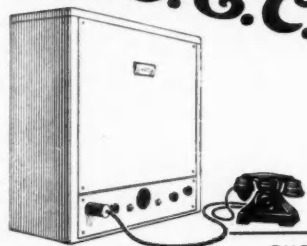
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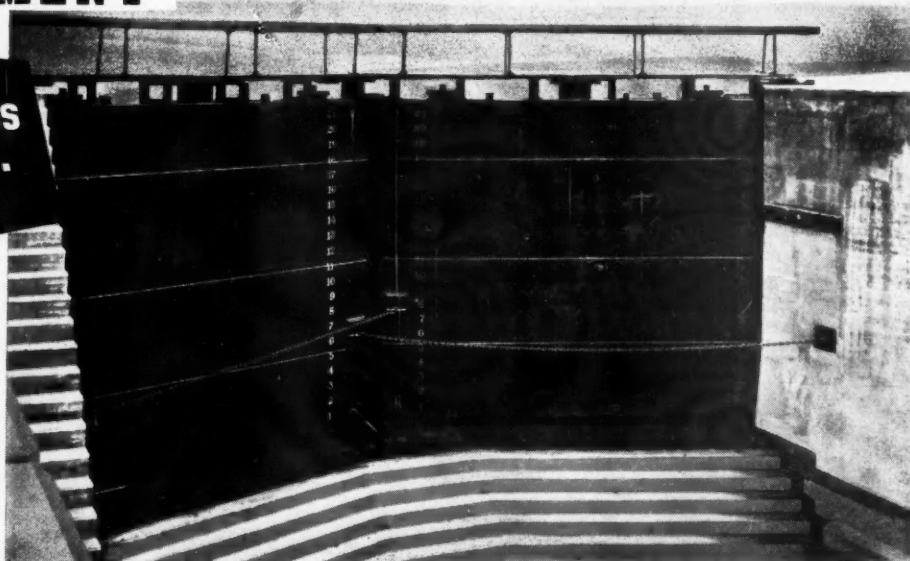
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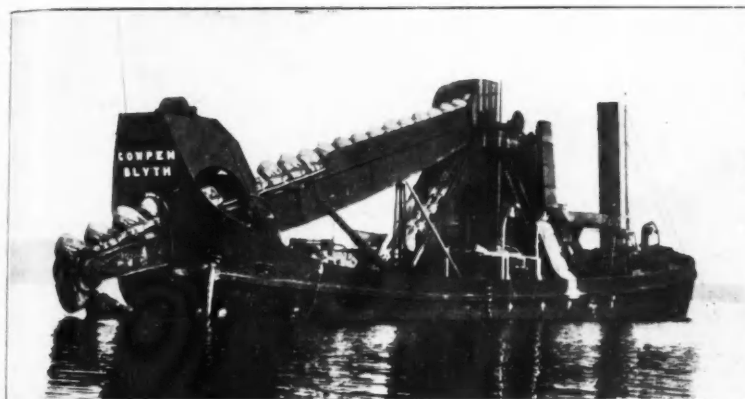


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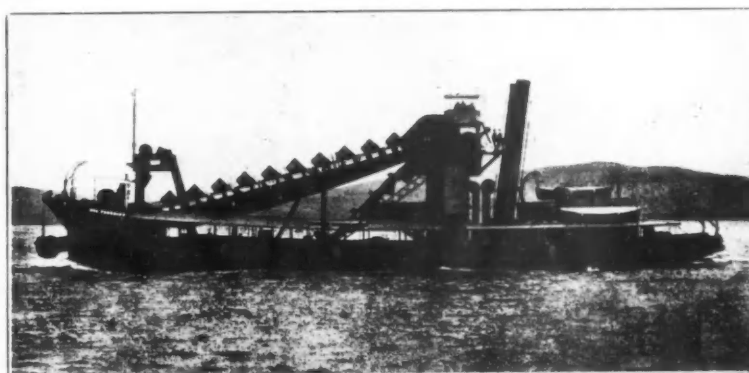
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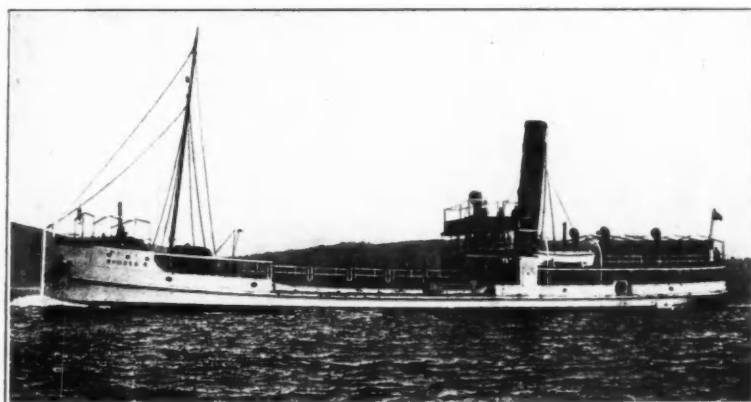
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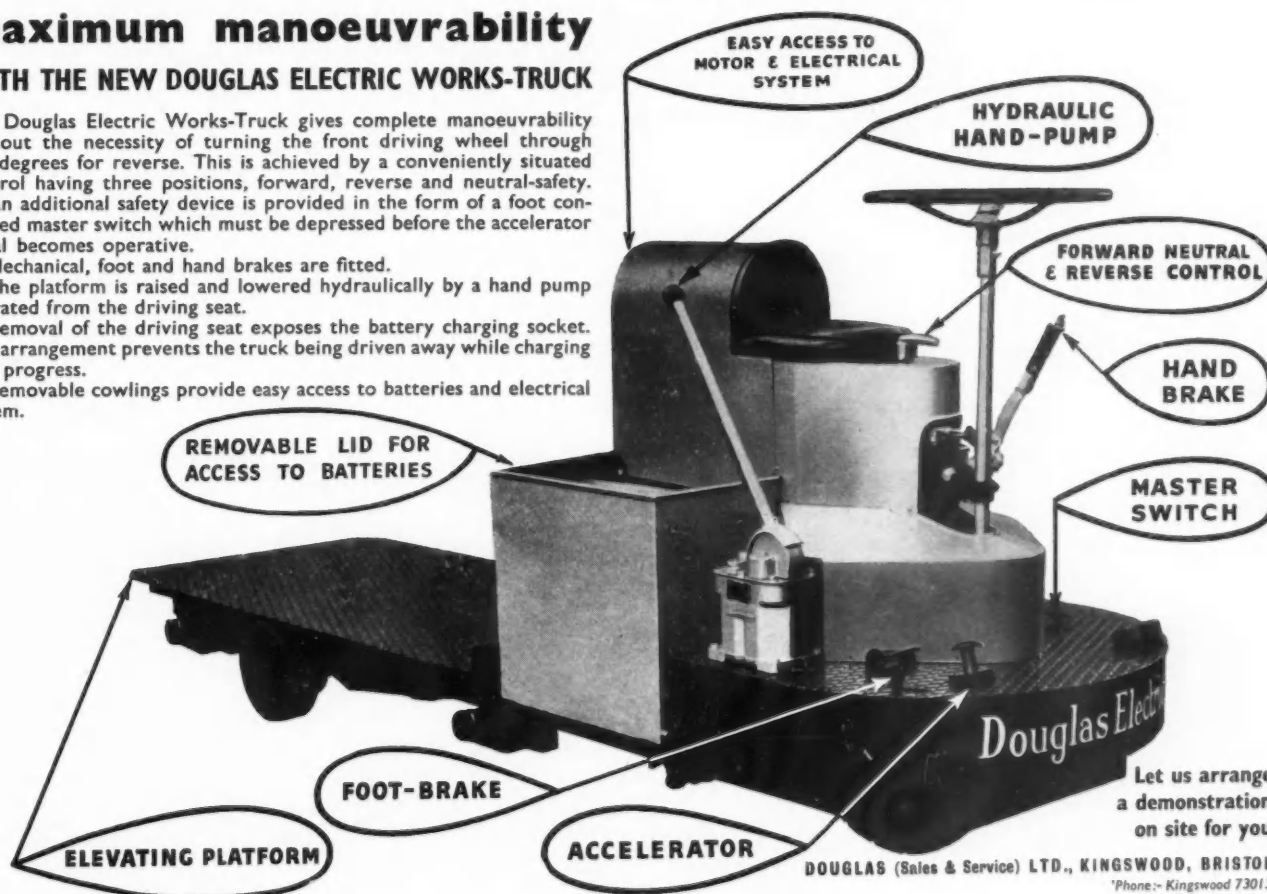
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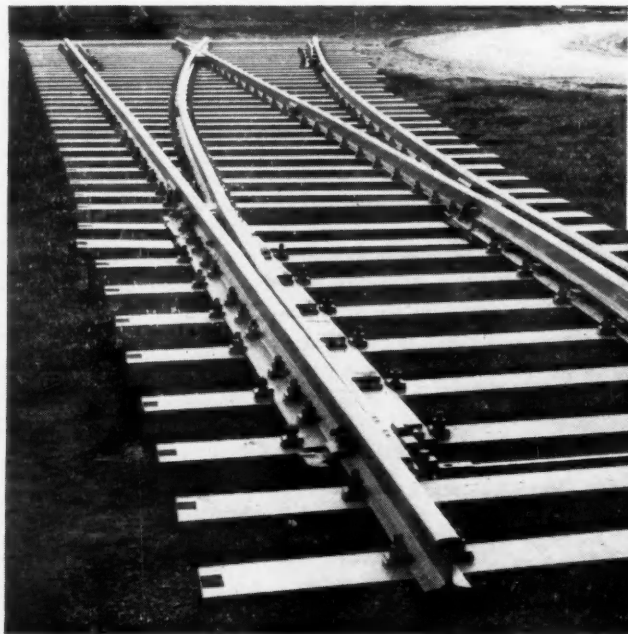
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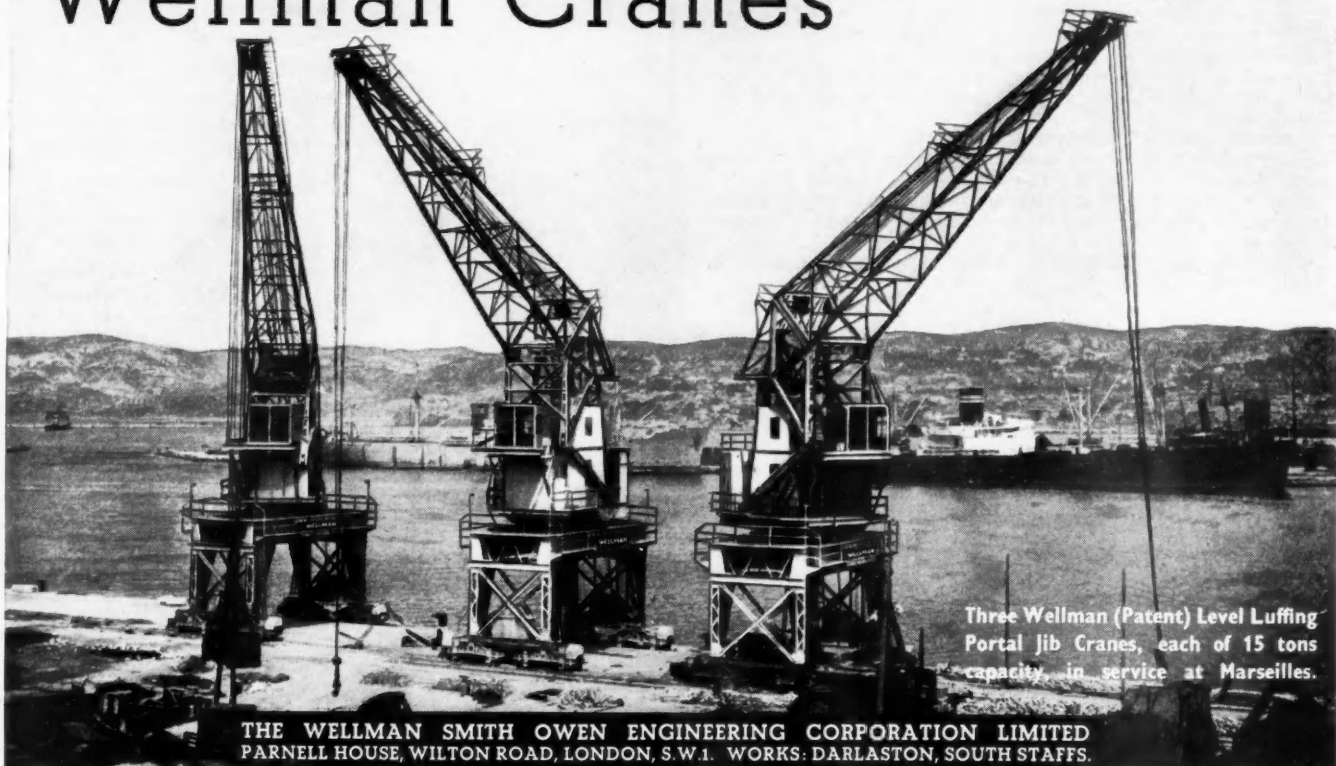
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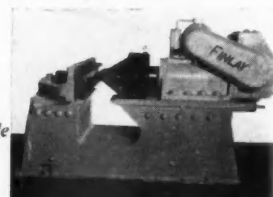
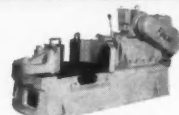
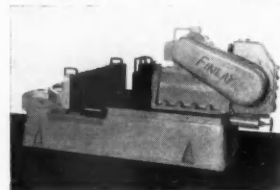
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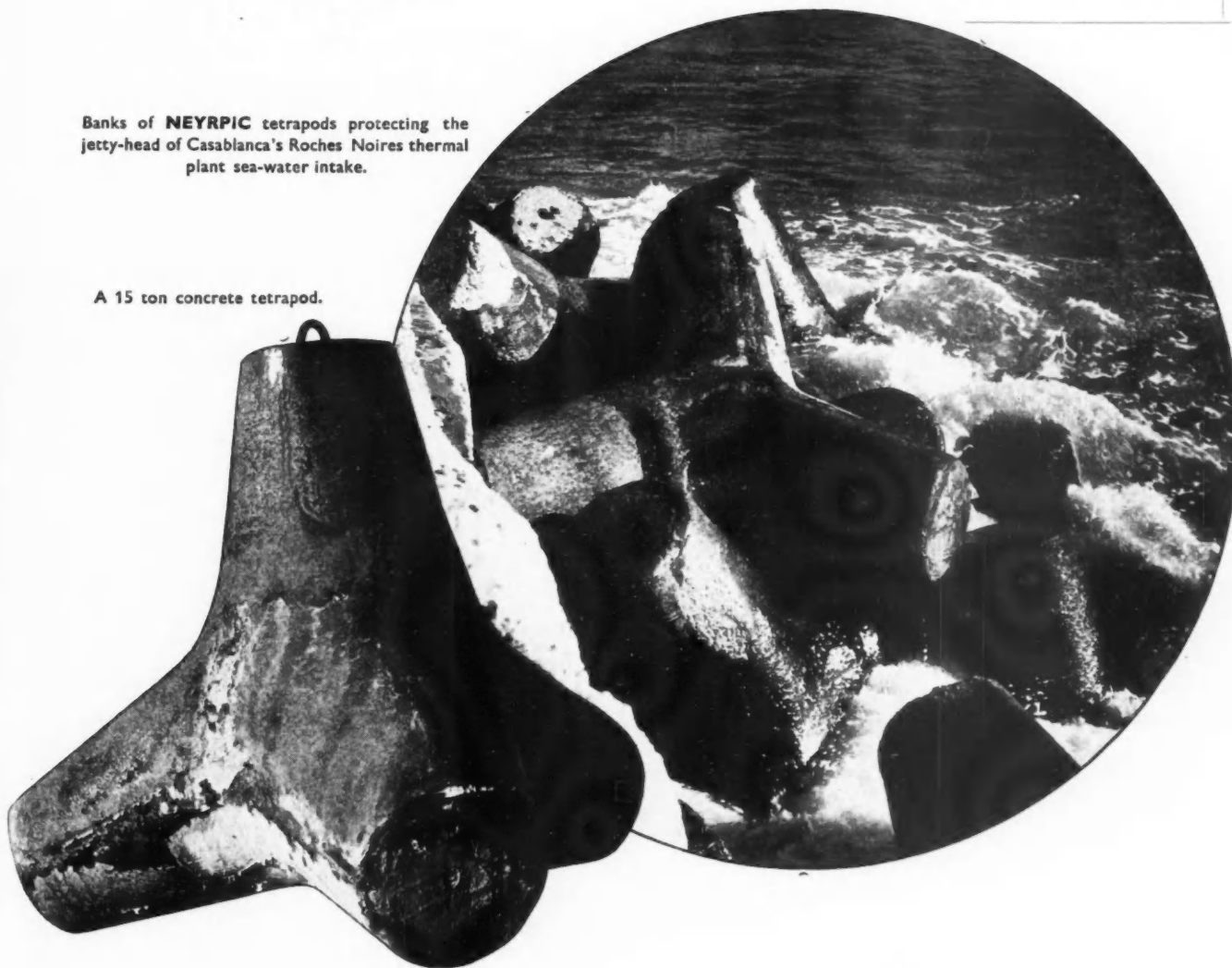
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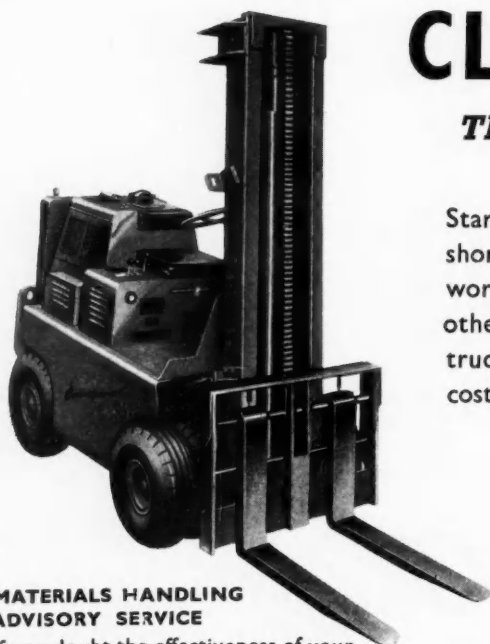
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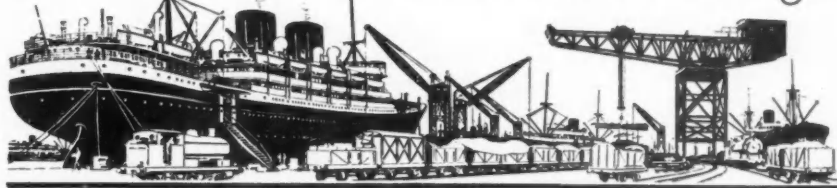
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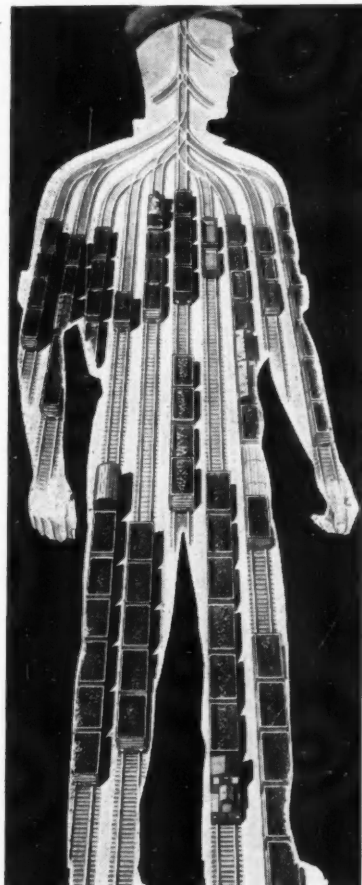
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CONTENTS

EDITORIAL COMMENTS	257
THE PORT OF CHERBOURG	259
PORTS AND SHIPPING TURN-ROUND	264
COALING INSTALLATION AT ABERDEEN	267
PALLETS AND THE PORT INDUSTRY	269
STRUCTURAL TIMBER FOR DOCK WORK	271
REINFORCED CONCRETE SHIP CAISSONS	277
CORROSION AND PRESERVATION OF IRON AND STEEL	282
THE CHOICE OF A GRAB	285
MANUFACTURERS' ANNOUNCEMENTS	287

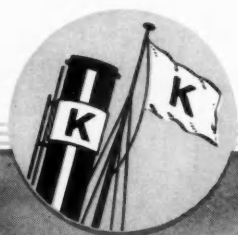
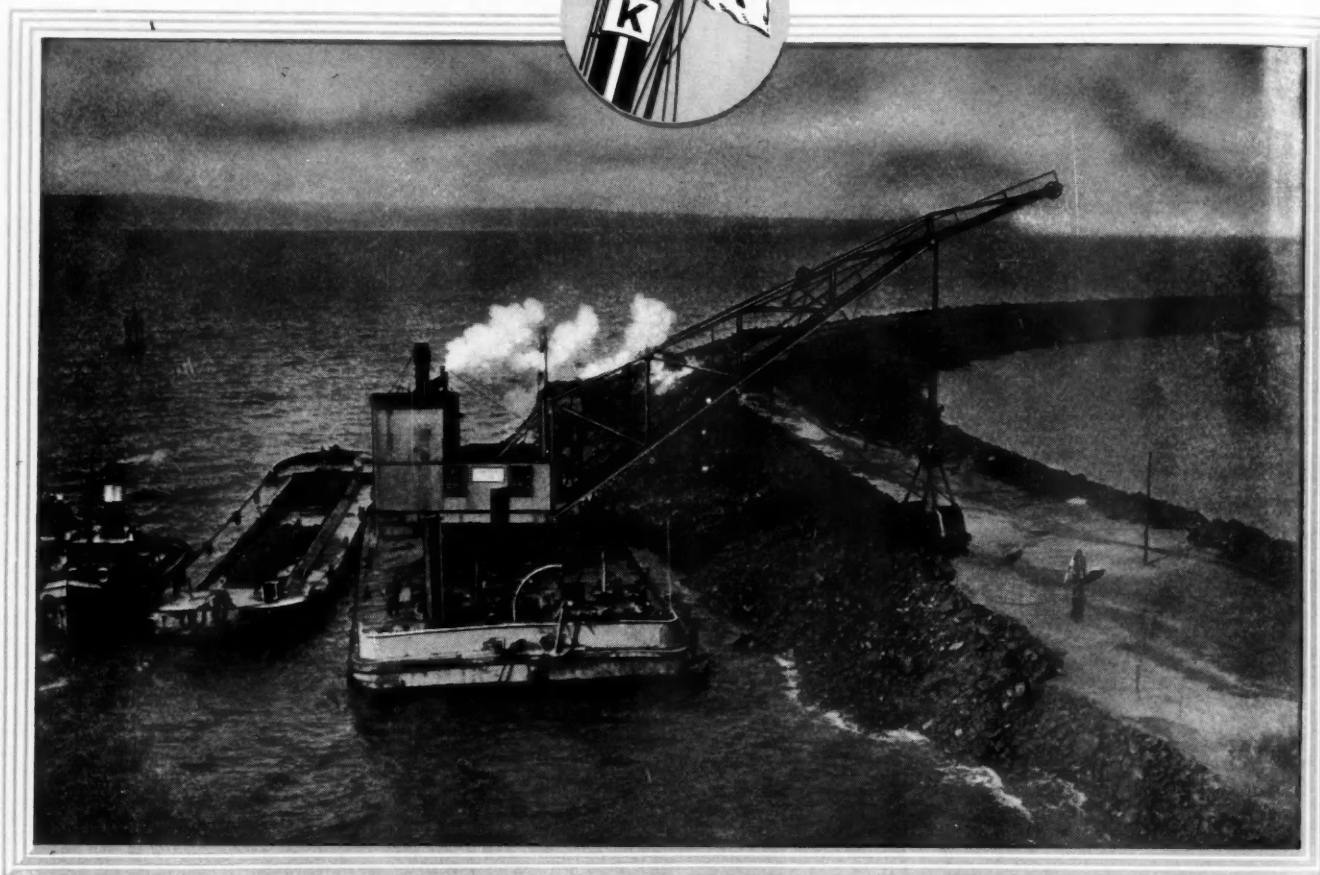


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The Dock & Harbour Authority

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No. 387

Vol. XXXIII.

JANUARY, 1953

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Editorial Comments

The Port of Cherbourg.

In common with a large number of French ports during the last war, Cherbourg suffered extremely heavy destruction before being liberated by the Allied Forces.

Regular readers of this Journal will remember that in our editorial columns for June last, we referred to two important events in the history of the port, the first visit since 1939 of the *Queen Mary* to the Quai de France in May, 1952, and the inauguration in that month of the new buildings of the Gare Maritime which, like the former, had been completely wrecked during the hostilities. The hope expressed in the course of our remarks of being able to publish some details of post-war reconstruction work is fulfilled in the present issue, and an instructive article by M. P. L. Brosson, which will be found on a following page, will, we think, be of general interest.

Occupying a strategic position on the north-west coast of France, Cherbourg, in addition to its commercial activities, is also a naval base. The naval and commercial harbours are separate, and about half a mile distant from each other. The latter consists of two parts—an outer tidal harbour and an inner basin having a depth of water at Ordinary Spring Tides of 25 feet. The Quai de France and the Quai de Normandie lie on the south side of the outer harbour.

Outside these harbours is the triangular bay which forms the magnificent roadstead of Cherbourg. It is sheltered naturally on all sides except the north, where is situated the massive breakwater, $2\frac{1}{2}$ miles in length with a width of 650 feet at its base and 30 feet at its summit, which is protected by forts and leaves passages for vessels to the east and west.

Originally intended for military and naval use, the initial design of the harbour installations is ascribed to the distinguished French military engineer, Vauban, who was responsible for the construction of a large number of continental fortresses, which remained in use until after the Franco-Prussian War of 1870. The works were begun in the reign of Louis XVI, resumed by Napoleon I, and finally completed by Napoleon III. For many years, however, the naval importance of Cherbourg has receded, and its chief function to-day is that of a port of call for transatlantic liners, the berths of which had been commenced in 1928.

The principal item of interest in the reconstruction of the Quai de France is the method of casting the "facing" caissons in segments connected together to form a monolithic structure by prestressing methods. Readers will find also much data and information of interest in both the design of the works and the methods of construction which were adopted.

Freedom of the Docks.

A judgment last month by Mr. Justice Sellers in the Queen's Bench Division is one of exceptional interest to tug owners, the shipping industry and dock authorities.

The plaintiffs, Messrs. J. H. Pigott, a Grimsby firm of tug owners, were granted a declaration that they were entitled to send their tugs to tow ships into and out of Immingham Dock without let or hindrance and were awarded costs against the dock owners, the Docks & Inland Waterways Executive. The firm is a family concern which has provided tug services since 1886, and in 1951 extended its services to Immingham and acquired two additional tugs to cater for the obvious need arising from the greatly increased

trade at the docks. The defendants challenged the plaintiffs' right to continue to provide this service, and in March last threatened to exclude their tugs.

As "The Times" commented in a recent leader article, the question of law in this case resolved primarily on the meaning of an enactment of 1847, which is incorporated in most special dock Acts giving the public the right of access to docks "for the shipping and unshipping of goods or embarking or landing of passengers." The Docks & Inland Waterways Executive had asserted wide rights to deny the use of Immingham Dock to private commerce, and their contention, if successful, might have enabled them to exclude from the docks, if they so chose, not only privately owned tugs, but even ocean-going vessels entering for bunkering. In particular, they would have been enabled, as they did in fact desire, to exclude tugs of a private company from towing vessels into and out of Immingham Dock, in order to prevent competition with their own tugs.

This judgment is of far more than local interest and importance, for it raises an important principle. As Mr. Justice Sellers found, although the traffic in Immingham Dock has greatly increased in recent years, the Executive's tugs there have often been idle and lost trade to private competitors, who apparently have been supplying a more attractive service. It would appear to have been to the benefit of the public that the Executive should improve its own services, rather than claim the right to exclude the tugs of a privately owned company, except on their terms.

The Judicial decision is in the tradition of Judges in the past, who have so construed Acts of Parliament as to make them workable in the spirit in which they were passed, and the present interpretation of the law conforms to the dictates of commonsense and sound commerce. It gives the public confidence that, in this sphere at least, public ownership will not mean diminished efficiency, for there will be the pressure of competition to ensure the best possible service to the public.

We are in agreement with the comment of "Syren and Shipping" when they say that the attitude of the Docks & Inland Waterways Executive in this instance "does not accord with our general knowledge of the operation of the Executive, who, placed in a generally unpopular and somewhat invidious position by the Transport Act, have, on the whole, carried out their duties with efficiency and to the satisfaction of those who had been accustomed in past years to the service of competitive undertakings."

Corrosion of Iron and Steel.

Corrosion, the destruction of metals by chemical or electrochemical agencies, is one of the principal items of maintenance costs with which all users of metals are faced, and this is particularly so in the case of iron and steel employed in maritime and marine engineering.

In view of the shrinking supplies of iron and other metals throughout the world, and the continuous increase in labour costs, there is increasing recognition on the part of both industry and public authorities of the growing economic implications of the corrosion of metals, and the subject has become one of far-reaching importance.

On a following page is printed the first instalment of an article devoted to Corrosion and Preservation of Iron and Steel, with particular reference to structures met with in dock installations

Editorial Comments—continued

and maritime engineering generally. The author briefly reviews the lines upon which some of the more important research work has been carried out in respect of certain aspects of corrosion, while in the second instalment, he outlines the principal preventive measures that may be taken to protect steelwork from corrosive action.

There are, of course, several other aspects of preservation of iron and steel of equal importance, but beyond the scope of the present article. In this respect the perfection of anti-corrosive coatings for ships' hulls might be mentioned, in which a considerable measure of success has been attained by the use of compounds of natural and synthetic rubber, the technique of which, in certain cases, has been applied to structural steelwork.

The principles involved in corrosive action are complicated, and research in many countries has given us a much clearer picture of many of the processes involved in the varying situations and circumstances in which corrosion occurs. As our contributor points out, however, the whole subject of corrosion and preservation is still at a somewhat inconclusive stage of development.

For example, it was reported only last month that iron articles left in waterlogged clay at Hungate, Yorkshire, some two thousand years ago, have been recently discovered in a remarkably good state of preservation. In such a soil, by all the laws of corrosion, such metals should have disintegrated into red rust within a few years. It has been shown, however, by the Corrosion Research Laboratory Department of the D.S.I.R. that preservation was due to the presence of leather cuttings and shoes buried with the metal, and that the tannic acid compound from the leather suppressed the activity of sulphate-reducing bacteria. It seems probable that this discovery may be usefully adapted to the problem of underground corrosion of iron gas and water mains.

The question of design of steelwork structures exposed to climatic conditions has been stressed by many authorities as being one of the principal factors in overcoming corrosion propensities. In this respect the designers of modern welded steelwork should be able to give considerable help.

Preservation of steel is one of the essential means whereby diminishing supplies may be alleviated to some extent. If, therefore, our contributor has in any way assisted by indicating in a simple manner the general principles of corrosion and preservation, and has focussed some attention upon the importance of the subjects, his article will have served a useful purpose.

Proposed Scandinavian Quarantine Area.

A proposal to combine Denmark, Norway and Sweden into one quarantine area is being considered by the governments of the three countries concerned, and a draft agreement was drawn up at a recent meeting of ministerial delegates at Gothenburg.

The purpose of such an arrangement would be that persons, ships and aircraft of the three countries should be able to pass each other's borders in either direction without quarantine inspection; persons and transport material entering one of the countries from the outside would also be able to pass into the others without further quarantine formalities.

Such an agreement, which still has to be ratified by the three national parliaments, must obviously be confined to a comparatively limited area, as too much latitude would defeat the object of the plan. There is no question, however, that it would save much time and labour, especially in the event of epidemic disease subject to quarantine restrictions breaking out in regions in the immediate neighbourhood of Scandinavia.

Topical Notes

Turkish Port Development Programme.

The Turkish Government announced recently that the £18 million programme begun in 1946 to increase and modernise its merchant fleet is nearing completion. The programme has also included the modernisation of six ports, in addition to a considerable increase in the size of the fleet. Work on three of the ports has already been completed, and work on a fourth is expected to be finished within the next few months. Improvements in ports and harbours have included the building and modernisation of piers, wharves, warehouses and other facilities; the construction of lighter and small craft, basins and breakwaters, and road services, to provide better communications with the hinterland of ports not properly supplied by rail. Work on these projects has been completed at the ports of Trabzon, Istanbul and Iskenderun, while good progress has been made with the improvements at the port of Zonguldak. The programme also includes the development of the ports of Samsun on the Black Sea, and Mersin on the Mediterranean.

Radar for Rotterdam Waterway.

It was recently announced in Holland that the work of equipping the Nieuwe Waterweg (the approach from the sea to Rotterdam) with radar installations, to render it fog-proof, will be commenced early this year. The Nieuwe Waterweg covers a distance of just under 19 miles, and it will be provided with a chain of seven radar posts in inter-communication, at a total installation cost of 2 million guilders, and an annual running cost of nearly half-a-million guilders. The system to be used is a Dutch invention, named *Raplot*, enabling watchers from the shore to judge the distance between ships to an accuracy of a few yards. Recent accidents in the approach channel, which is used by an average of 75 ships daily, account for the decision to accelerate the execution of the full radar installation plans. Experience has shown that ships' own radar equipments, while of undoubted value, are not always reliable in such busy shipping lanes. The shore installations now about to be erected will enable the watching service to keep the Nieuwe Waterweg under careful observation all the time, irrespective of weather conditions.

Stockholm's 700th Anniversary.

It has been announced that the 700th anniversary of the City of Stockholm, which occurs this year, is to be celebrated from May 3rd until September 30th next. The official part of the programme is to take place on June 19th-21st under the auspices of the City Authorities. In addition, Stockholm trade and industrial organisations have contributed about 1 mill. kr. for pageants and festivities of various kinds to be held during the rest of the five months period. The fact that the town and port of Stockholm is protected by an Archipelago of numerous islands and inlets on the waters of Lake Mälär will lend special attraction to many of the arrangements. The Stockholm Chamber of Commerce, which is in charge of the festivities sponsored by trade and industry, has announced a competition for imaginative ideas to be used in connection with the festivities.

East African Transport Plans.

The question of increased transport capacity on the East African Railways and Harbours system was considered at a recent meeting of the Transport Advisory Council held in Nairobi. Important matters dealt with included the draft estimates of revenue and expenditure for the current year, which were recommended by the Council for submission to this month's meeting of the Central Assembly. These draft estimates provide for a revenue income of over £16 million and a works and equipment programme of £50 million, of which over £7 million is for port services. Among the new works recommended were sidings for industrial areas at Dar es Salaam, Arusha and Morogoro, additional lighterage at the sea-ports, and the provision of additional cranes at the ports of Tanga and Mombasa. It was also recommended that a dockyard for the maintenance of small craft owned by the Administration should be established at Mombasa. A scheme of private long-range wireless communication between East African ports was also suggested to facilitate shipping movements and cargo handling. The Council were informed that the work of constructing two new berths, Nos. 9 and 10, at Mombasa had been placed with Braithwaite & Co., Ltd., who were to utilise screw-piles to overcome foundation difficulties. It was expected that the quays would be completed towards the end of this year or early in 1954, but that the berths, complete with transit sheds, would not be available for public use until some months later.

The Port of Cherbourg

Reconstruction of "Quai de France"

By *Al INGENIOR P. L. BROSSON.*

CHERBOURG, the "Gateway of France," situated at the point of the peninsular Contentin, became the "Gateway of Liberation" in 1944. Open to all the naval convoys of the allied forces, its port dealt with a daily traffic which reached 27,000 tons in spite of the heavy destruction of its structures and the congestion of wrecks that blocked it.

The lay-out of the Port of Cherbourg was not completed in 1939. A transatlantic basin of 230 m. width lined by 1,200 m. of quays, dredged or cleared of rocks, offered a depth to -13.00 in the northern part and -12.00 in the southern part.

In the west the "Quai de France," intended for berthing in all phases of tide, of the biggest transatlantic liners, stretched over 620 m. in front of a magnificent and imposing harbour terminal, which permitted the simultaneous berthing of two of the biggest liners of the Atlantic Lines.

In the east the "Quai de Normandie" was located, having also a length of 620 m., of which, however, only half was usable.

The construction of the quays and the harbour terminal which was started in 1928 but interrupted before the Second World War, had been entrusted to Messrs. Christiani & Nielsen.

The dredging and clearance of rocks of the transatlantic basin and its approaches, as well as of the earth fillings, had been in the care of the *Entreprise de Travaux Publics de l'Ouest*.

In June, 1944, before their surrender, the German troops defending Cherbourg perpetrated extremely heavy destruction. The quays were blown up by mines and the harbour terminal was two-thirds destroyed.

After the American Army had captured Cherbourg the harbour was rapidly repaired and provisional works of a considerable magnitude were executed. In September, 1944, 28 liberty ships, two ferry boats and more than 100 coasters, lighters, etc., could berth simultaneously within the enclosure of the port of Cherbourg. At that time, "Cherbourg was the most important centre in the world for the supply of the allied forces and conveyed more than half of the goods transported by the U.S. Army all over the world." Quotation from the report of the American commander of the port of Cherbourg).

In October, 1945, the American Army delivered the port of Cherbourg to the French authorities and the reconstruction of the "Quai de France" was investigated.

After a call for tenders the works were entrusted in September, 1948, to Messrs. Christiani & Nielsen, Paris, and to the *Entreprise de Travaux de l'Ouest*, Nantes.

The former quay wall consisted of a line of reinforced concrete caissons, each 33 m. long and 6.20 m. wide, sunk by means of

compressed air and founded at levels varying from -13.00 in the south to -21.00 in the north.

The caissons served as retaining walls for the virgin ground under level -5.00 as well as for the fill above. A slope of broken stone extended from the top of the filling (level +7.80) down to the virgin ground at level -5.00 behind the caissons.

A number of weep-holes, between from level -5.00 and level 0.00, allowed the equalisation of the water levels on both sides of the quay at any state of the tide.

A reinforced concrete floor 16 m. wide connected the upper part of the caissons with the crest of the stone slope (+7.80), and was partly supported on the caissons proper and partly on a row of piles driven to the rock.

German Destruction.

Mines placed about every 40 m. in level -5.00 against the back of the caissons at the foot of the stone slope resulted in:

the collapse of the reinforced concrete flooring,
the dislocation of the stone slope supporting the fillings,
the heavy shaking of the caissons with the creation of breaches in certain places down to level -9.00,
the cracking, the sliding and the tipping of the caissons in other places.

Provisional Reconstruction.

In order to make the "Quai de France" ready for use as quickly as possible the American Army, provided with exceptional

and powerful equipment, cut down to level -8.00 the crest of the slope of the debris from the demolitions, which blocked the bottom in front of the quay, constructed a strongly built wooden pier supported by a forest of piles placed on the old caissons or driven through the rubble behind them.

This pier, protected on the harbour side by groups of fender piles, allowed the resumption of an intensive exploitation during the military operations and later the return of the port to commercial traffic.

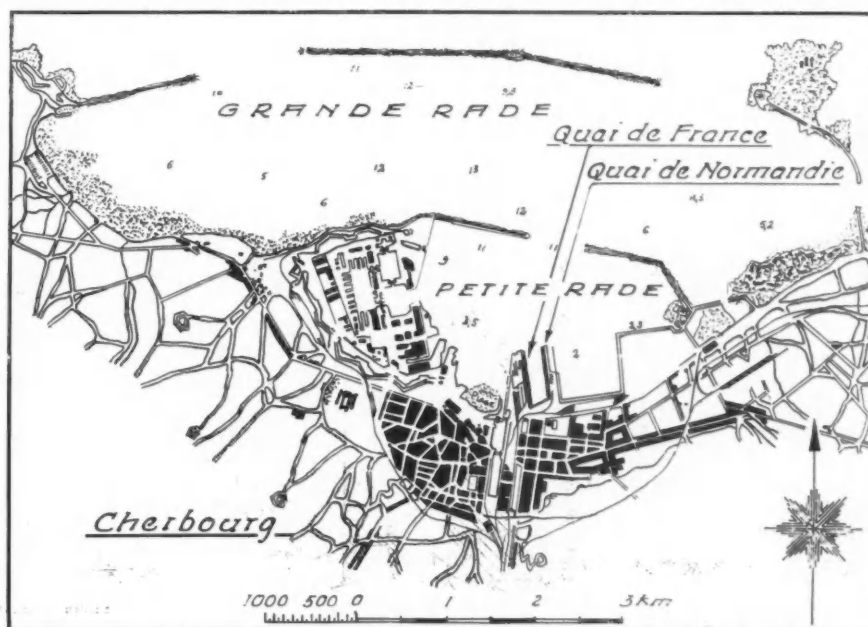
PERMANENT RECONSTRUCTION

The Project.

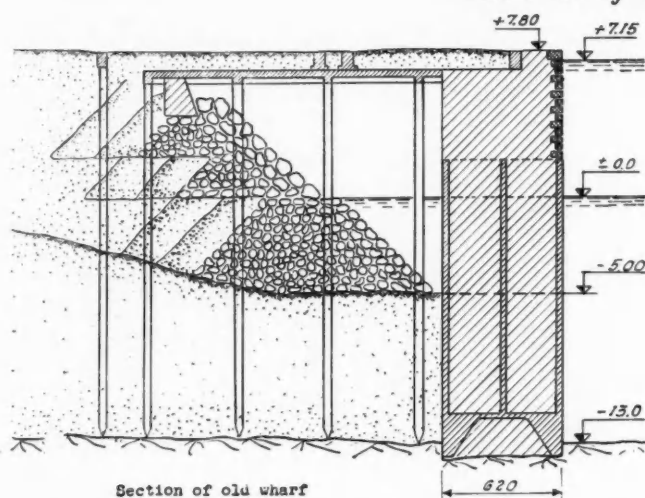
Because of the considerable masses of rubble of all kinds which had been thrown behind the quay, and the displacement of the stone slope, reconstruction of the quay in its original form and dimensions (width 6.20 m. slope from -5.00 to +7.80 and flooring on piles) was out of the question.

It was, therefore, contemplated to fill in right up to the full height of the quay wall, and to widen the quay sufficiently to ensure its stability. But this course would render it necessary to remove the old shaken or dislocated caissons and to make an effective connection between the old and the new masonry in order to allow the transmission of the internal forces.

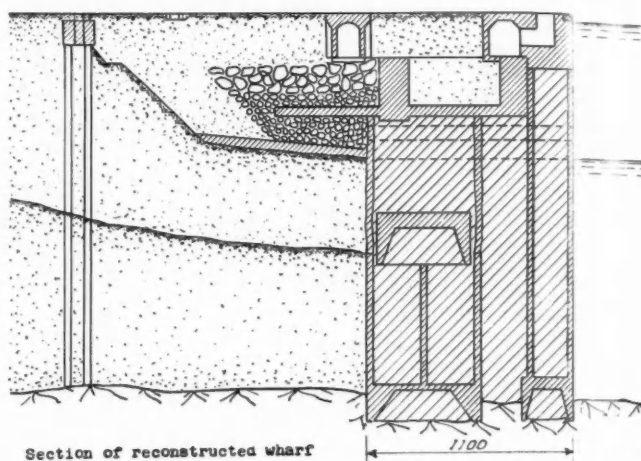
The stripping of the first length of flooring enabled, however, the full extent of the destruction to be ascertained: Certain caissons had slid several meters out into the harbour,



The Port of Cherbourg—continued



Section of old wharf



Section of reconstructed wharf

others had disappeared and what remained of the old masonry was greatly dislocated far below the lowest tide and presented large horizontal or vertical cracks filled with earth and rubble.

Under these circumstances it seemed impossible to carry out the work necessary to ensure that the structure would work as a monolith and have in all sections the necessary width. Therefore, the contractors studied, together with the administration, a design which was stable in itself, independent of the old masonry.

This new structure which involved an encroachment of 4.80 m. towards the basin, has the shape of an angular frame with counterforts and rests on the rock and on the old quay.

The support on the rock is continuous being the support of the working cham-

bers of the facing caissons founded in front of the old quay.

The support on the old quay is discontinuous being the support of the counterforts furnished by the working chambers of the pier caissons sunk into the sound parts of the old masonry.

In this new structure stability is assured by the weight of the new parts and by the bracket action of a slab connected with the facing caissons at level +2.40.

The New Quay Wall.

The widening of the quay towards the harbour basin is obtained by placing a continuous line of reinforced concrete caissons (called "facing caissons") at a distance of 4.80 m. in front of the former quay line. They have each a length of 8.00 m. with joints 0.33 m. and a width of 2.30 m., in-

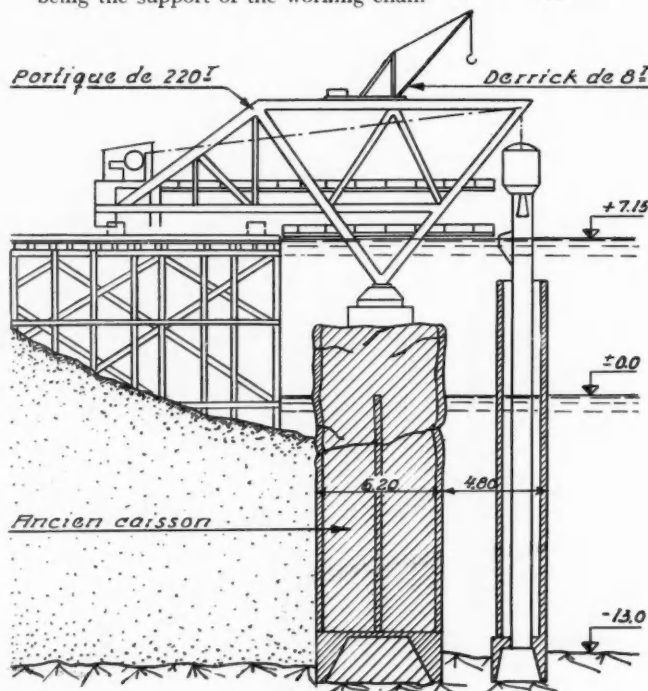
creased to 2.60 m. in the working chamber.

The space of approximately 2.50 m. between the new caissons and the old quay is filled with underwater concrete embodying reinforcement bars inclined 45° downwards and designed to transmit the shearing forces between the facing caissons and the concrete filling.

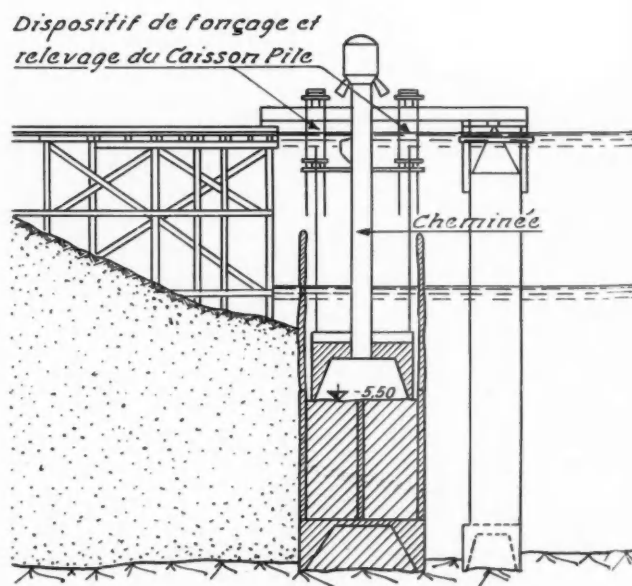
The facing caissons are partitioned vertically in three cells 1.96 m. by 2.46 m. and are filled with concrete after having been sunk by compressed air.

To assure an effective connection between the old and the new structures and in order to ensure the stability of the quay through a bracket action, a ribbed slab 0.50 m. thick caps the 11 m. wide construction at level +2.40.

The stiffening of this slab is obtained by ribs 3.25 m. high transmitting the forces to



Founding 'facing' caissons, using compressed air



Reconstruction of old wall, using compressed air

The Port of Cherbourg—continued

two longitudinal distributing beams, one in the back and one in the front.

The rear beam is placed over the rear of the old caissons between level +2.00 and +5.50 and has as its object the distribution of the weight of the slab over the counterforts.

The front beam is placed on the facing caissons between level +5.00 and +6.50 and has the double object of distributing the pressure of the different caissons on the rock and of rendering uniform, in the longitudinal direction, the tensile forces developed by the bracket action of the slab and concentrated in the counterforts.

The counterforts which recur every 16.66 m. and have a thickness of 3.15 m. over

the depth of the rock. These facing caissons are cast in elements on a concrete floor, whereafter the elements are assembled on their launching slip by the prestressing procedure of the S.T.U.P. After having been launched they are floated in a horizontal position to their permanent site where they are lifted and suspended from a portal crane which maintains them in a vertical position until they have been sunk into position by means of compressed air.

Design of the Caissons.

The lower part of the caissons is made of one first element 2.40 m. high and 2.60 m. wide forming the working chamber on the ceiling of which a dismantable steel tube

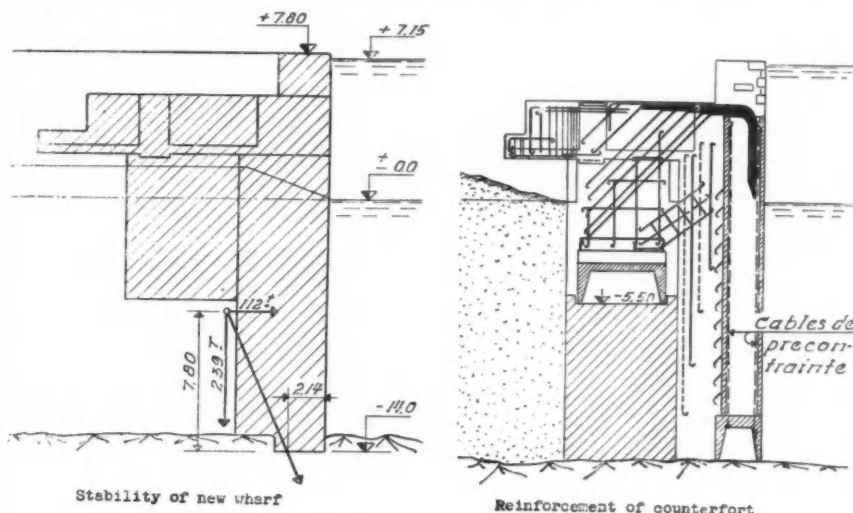
Building of the Facing Caissons.

The reinforced concrete elements of the facing caissons are fabricated in a construction yard especially provided for that purpose.

The number of casting platforms is such that three caissons can be cast simultaneously which, with the delays in hardening taken into account, permits an output of one caisson a week, while two other caissons are in the course of assembling on two launching slips.

Shuttering.

Steel shutters of the system "Cofral" were used in combination with vibration of the shuttering. They comprise:

**GLOSSARY.**

Grande Rade	- - -	Outer Roadstead.	Relevage du Caisson	- - -	Suspension of Caisson.
Petite Rade	- - -	Inner Roadstead.	Pile	- - -	Working Chamber.
Caisson de Pavement	- - -	Facing Caisson.	Ancien	- - -	Old.
Cheminée	- - -	Air Lock Shaft.	Coupe	- - -	Section.
Portique	- - -	Movable Crane.	Cables de Pre-contrainte	- - -	Prestressed Cables.

the width of the old caissons, serve the following purposes:

- (1) to pick up the loads of the slab transmitted through the rear distributing beam and to transmit the corresponding forces to the facing caissons,
- (2) to increase the moment of inertia of the cross section of the new quay, regarded separately, while also contributing by their own weight to improve the stability,
- (3) to provide a support towards the rear by means of the pier caissons sunk by compressed air through the openings of the old caissons, and have a solid base at varying levels (-5.00 to -9.00) on the parts of the old masonry which have remained sound.

At the back of the quay wall, thus formed, the filling up is made by a mass of rock rubble.

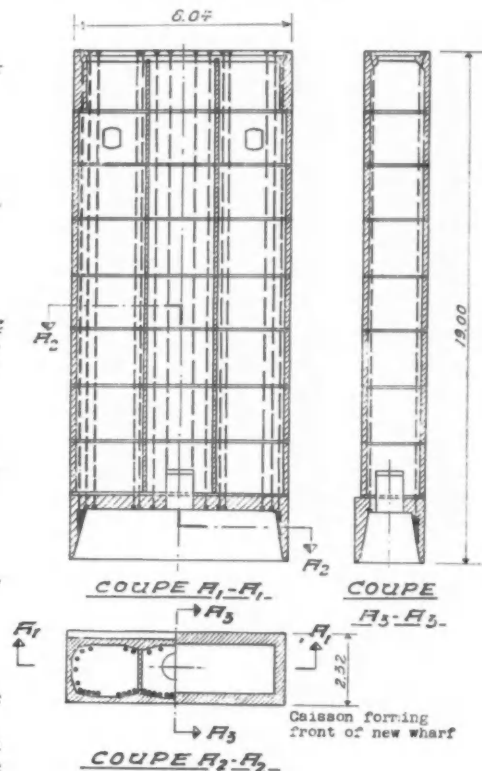
The front of the "Quai de France" is made up by a row of 73 reinforced concrete caissons measuring 8.00 m. in length and from 19 m. to 26 m. in height according to

is fastened. The tube is recovered when the sinking has taken place.

On the top of this working chamber a certain number of normal elements are added, each measuring 2.00 m. in the height and 2.30 in the width, partitioned in the interior by two ribs dividing the section of the caisson into three cells of 2.46 m. by 1.96 m. These elements, which vary in number according to the height of the caisson, are designed to resist a hydrostatic pressure of 10 t/m² for the first elements placed on top of the working chamber, and a pressure of 5 t/m² for the upper elements.

The last of the upper elements is provided in its end cells with two reinforced concrete tubes with opening of 0.50 m.² designed to serve as weep-holes at about level +1.00 after the sinking of the caisson, and to ensure the hydrostatic equilibrium on both sides of the quay wall.

The last element, the so-called top element, measuring 2.20 m. in height and designed for a pressure of 2 t/m², is provided in its upper part with holes for the passage of the lifting gear of the crane.



outside, four large panels of the same dimensions as the faces of the elements, inside, three steel frames of the same dimensions as those of the cells.

Assembly of the Elements.

A travelling 60 ton portal crane transported the concrete elements from their casting platform to one of the two launching slips where they were laid down and joined on a cradle, starting with the working chamber placed at the bottom.

After scarifying the surfaces of the upper and lower parts of each element, a 3 cm. mortar joint of rich mixture and well compacted, assures the continuity and the watertightness between each pair of elements.

Prestressing.

It is solely by means of the prestressing through the full height of the caissons that

The Port of Cherbourg—continued

the 9 to 10 elements that constitute each of the caissons, are connected monolithically into one single block of 10 to 26 m. height.

This prestressing, carried out according to the methods of S.T.U.P. (the Freyssinet method), was effected by 42 to 54 cables, of twelve 5 mm. wires each, whose anchoring cones take their support on the walls of the working chamber and on the upper part of the top element.

This prestressing not only assured the perfect rigidity of the assembled structure during the launching operations and the placing of the caisson, but was also useful for distributing the forces in the quay wall.

The cables were coated with "bitumastic" in order to secure their preservation between the moment when they were stressed on the cradle, and until embodied in the underwater concrete, poured into the cells after the sinking of the caissons.

Launching of the Caissons.

Two launching slips of 45 m. length, sloping 16% between the level +8.25 and +2.20, permitted the launching of the caissons at all high tides and even at neap-tides.

Before being launched the caisson was equipped with its steel tube for the sinking by compressed air, and on the top element the lifting eyes for the suspension in the crane were placed. A wooden panel covered the upper part of the top element, while a steel plug closed the opening of the steel tube in the ceiling of the working chamber.

Once in the water and floating freely, the caisson had an inclination of only 0.09 to the horizontal.

Further, in order to improve its buoyancy and especially its stability in the longitudinal direction, the caisson was fixed to buoys at its working chamber for the duration of its transport.

From the construction yard and to the "Quai de France," a distance of about 1500 m., the towing of the floating caisson was carried out by a tug at an average speed of 1 m./sec.

Placing of the Caissons.

When the caisson had reached the "Quai de France," in a position at right angles to the quay, it was hooked on to the suspension crane by two pegs put through the lifting eyes of the top element and connected to the six sheave purchase tackle.

When the caisson had been freed of the buoys, the winch was put into action to effect the lifting of the caissons.

In order to avoid too great an overpressure on the walls of the lower elements, when according to its height the caisson drew from 13 to 14 m. of water, a certain quantity of water was let in through the bottom valves, thereby facilitating its rising at the end of the operation.

When the caisson was in a vertical position and the falling tide allowed, the caisson was grounded on the bed which had previously been prepared on the rock.

After grounding, the cells were opened to



The placing of a caisson facing.

let in the sea water and the fitting out, needed for the sinking by compressed air, was completed.

The crane for handling the facing caissons was a movable steel crane capable of lifting 220 tons. It was supported on the staging (+7.80) on which it travelled and on struts resting on the old caissons cut down to level +2.00. With a width of 8 m. it carried, during the whole period of sinking, the caisson suspended at the two extreme ends of its top element.

The weight of the steel frame and the counterweight totalled 145 tons. It was equipped with two Berliat winches, each operated by two 7½ h.p. motors which lifted

the caissons to their vertical position at the lifting rate of 12 cu./min.

At the top the crane was surmounted by an 8 ton derrick, necessary for the mounting and dismounting of the equipment of the caissons. At the level of the winches it carried also the concrete mixer needed for the filling of the working chamber with concrete when the sinking was completed.

Sinking of the Caissons by Compressed Air.

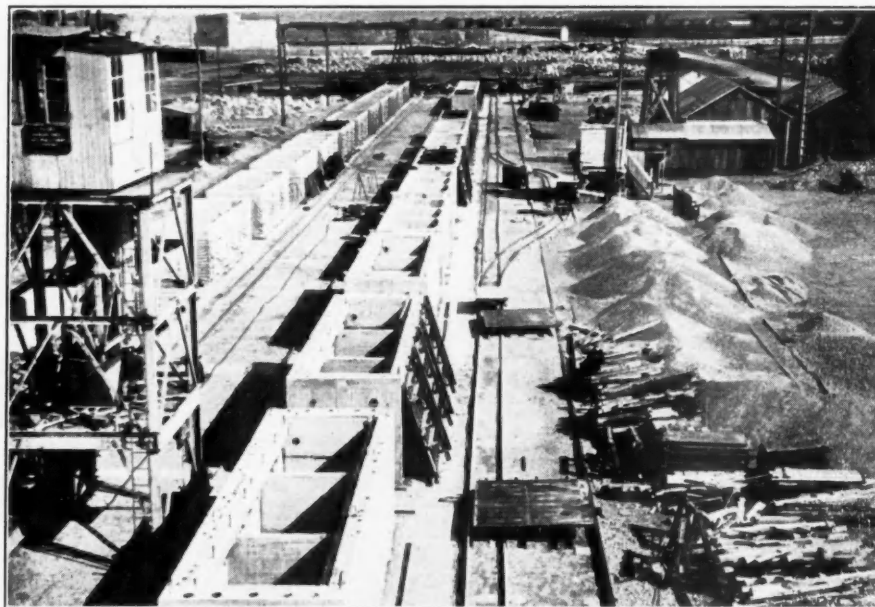
The sinking by means of compressed air had as its object, to embed the facing caissons from 0.50 m. to about 1 m. into hard and sound rock.

The caissons suspended vertically from the portal crane during the whole period of their sinking, rested lightly on the rocky sea bed on the edges of the working chamber. Their equipment consisted of one single steel tube having at the top a concrete lock which in its turn is crowned by a Fives-Lille air-lock for the passage of personnel and excavated material.

In view of the short height of sinking, 2 m. maximum, the air pressure underwent only the variations due to the tide. Thus the work was done with a pressure varying from 1.4 kg./cm.² to 2.5 kg./cm.². It is only at the extreme end of the pier-head where, in the case of six caissons, the rocky bottom was situated at level -21.00, that the pressure was from 2.00 kg./cm.² to 2.7 kg./cm.².

The ballasting of the caissons was carried out by introducing water into the cells, and the excavation was done with a pneumatic hammer and a limited use of explosives in the hard rock.

The sinking gangs, which worked in three shifts, comprised seven men, and the sinking of each caisson was carried out in five days, and the concreting of the working chamber in compressed air was done in two shifts.



General view of fabrication of caissons.

The Port of Cherbourg—continued

A power house for compressed air, erected in the middle of "Quai de France," was equipped with two high pressure compressors 7 kg./cm.² of 80 h.p., one low pressure compressor 3 kg./cm.² and 50 h.p., and for relief: one high pressure Diesel 7 kg./cm.² and 80 h.p. This power station furnished the air, not only for the sinking of the caissons, but also for the whole of the working site of the "Quai de France."

A hospital equipped with a resting room, shower baths, and a medical air-lock received the compressed air workers at the end of each shift, the total number of whom was 30 on an average.

For 122,300 hours of work 70 accidents have been registered, i.e. one accident for every 1,760 working hours, divided as follows:

Accidents to both arms and legs	36.65%
" " legs	30%
" " arms	11.4%
" " the head	11.4%
" " the abdomen	5.7%
" " the ears	2.85%
" " lungs	1.45%
" " breast and head	1.45%

The Pier Caissons.

The counterforts which constitute the discontinuous support on the old quay were in the main composed of a working chamber in reinforced concrete, sunk through the openings of the old caissons. The ceiling supports the strongly reinforced counterforts made of underwater concrete.

The working chambers of these caissons, weighing 27 tons, were fabricated on the staging itself and placed by means of a 30 tons floating crane. They were sunk by compressed air while suspended in spindles supported on the staging and on the facing caissons already sunk and concreted.

The reconstruction of the 620 m. of the "Quai de France" entailed the use of approximately 86,000 m.³ of concrete, viz :



Lifting caisson prior to founding.

7,700 m.³ reinforced concrete for the fabrication of the facing caissons assembled by prestressing,
79,000 m.³ of cast-in-situ concrete.

For these 79,000 m.³, 60% of which represented concrete cast under water and 40% reinforced concrete cast in the dry at low tide or mass concrete for the filling of the working chambers, a concrete plant was installed in the centre of the working site, from which the distribution of the concrete was effected by specially constructed lorries.

The aggregates, supplied by lorries, were filled into two reception hoppers, one for the pebbles and gravel and one for the sand, from where two elevators with buckets raised the materials to a height of 20 m. and by

means of spouts pointing in different directions, distributed the materials into different silos with a working capacity of 350 m.³ of concrete. Corresponding to each of the two concrete mixers, a batching grab mounted on a monorail circulated under the silos where it was loaded and moved to be tipped into the loading skips of the mixers. These, situated at a height of 4 m. poured the concrete into 5 ton lorries equipped with two steel hoppers, each containing 1 m.³ of concrete.

The lorries carried the concrete to the vicinity of its point of application and poured it onto conveyors which effected the distribution. The flow of the concrete from the lorries was facilitated by the use of electric vibrators installed in the bottom of the hoppers thus allowing them to be completely emptied.

For the underwater concrete, for the casting of which a continuous feed of concrete in a perfectly watertight tube must be assured, the conveyors empty themselves into small regulating hoppers placed on top of the feeding columns.

The reconstruction work of the "Quai de France" was characterised by the method of building the caissons in elements and assembling these by prestressing.

This new technique of application of prestressing called for the installation of a construction yard especially equipped to that effect, but has at the same time allowed a saving in time and a gain in the economy of the job.

Commenced in September, 1948, the whole of the works were completed in the first months of 1952.

International Cargo Handling

Since its inception, the International Cargo Handling Co-ordination Association has developed through its membership a consultative service in relation to modern techniques of cargo handling. The value of this service has been proved by the success attending recent experiments with bulk cargoes in the Port of London and elsewhere, and in solving problems concerning the quicker handling of ships in port. Many projects are now under consideration for the development of cargo handling resources in countries whose ports, in many cases, lack good harbour facilities or equipment.

I.C.H.C.A. reports that Mr. F. J. Dowsett, who, until his retirement, occupied an important executive position with the Port of London Authority, is proceeding to Brazil as the Association's representative in a team of experts, who are to study harbour development schemes in that country.

On Thursday, 19th February, I.C.H.C.A. will hold, in London, a Symposium on Timber Handling, in which certain aspects of world timber trade will be reviewed, a new design of timber carrying ship described, and other matters relative to timber handling throughout the world discussed. The meeting will be held on board the "Wellington," the Headquarters Ship of the Honourable Company of Master Mariners.



General view of work in progress on the Quay de France.

Ports and Shipping Turn-Round

Causes of Delay and Suggested Remedies*

By A. H. J. BOWN, O.B.E., F.C.I.S., M.Inst.C.
General Manager and Clerk, River Wear Commissioners.

THIS address will consist of a central proposition with four sectors grouped around it. The central proposition is expressed in these words: "It is said that ships are spending too much time in port—especially in discharging and loading cargo." The four sectors grouped around that central proposition are, respectively, the background, the evidence, the causes and the cure. Let us consider the background.

In the United Kingdom, in the year 1951, the background consisted of over 300 ports: over 107 million net tons of shipping coming and going with overseas cargo: £3,914 millions of foreign imports: £2,707 millions of foreign exports: and 82,360 registered dock workers spread over 83 of the 300-odd ports. In addition to the overseas traffic, over 48 million net tons of coastwise shipping with cargo moved in and out of our ports. That sounds like a lot of shipping movement—as indeed it was—but it was actually 16% less than in the year 1938. The ten principal imports in 1950 were crude oil, meat, wool, food generally, raw cotton, grain and flour, dairy produce, beverages, refined oil, and fresh fruit and vegetables. The ten leading exports were vehicles, machinery, iron and steel, cotton goods, woollen goods, chemicals, electrical goods, non-ferrous metals and manufactures, food, pottery and glass, cutlery and hardware. About 60% of all that trade was conducted on two rivers, the Thames and the Mersey.

Cargo-handling in the ports of Great Britain is carried out by registered employers and by workpeople who are registered members of the National Dock Labour Scheme. The essence of the labour scheme is a guaranteed weekly payment in return for eleven guaranteed half-daily attendances in every working week. These conditions were first introduced on a provisional basis during the last war and were made permanent in the year 1947 by a Government Order having the force of law. The Labour Board administers the guarantee fund, pays all wages, finances holidays with pay, and takes care of welfare, education, training for specialist jobs, and medical centres at the docks. The Labour Board obtains its funds from the employers in the industry by collecting all wages payable to the men plus a percentage surcharge. The employers therefore pay more wages than they otherwise would, but in return the scheme aims to provide them with a regular labour force of good quality.

The workpeople's rates of pay, working arrangements and conditions of service are negotiated between their own Trade Unions and the National Association of Port Employers. Sitting together, these bodies form the National Joint Council for the Port Industry.

The national daily time rate is 22s. 6d. a day, paid on a half-daily basis, i.e. £6 3s. 9d. a week, apart from overtime: but the vast majority of the men are not on the time rate at all but are pieceworkers earning much more than £6 3s. 9d. a week. Gross earnings of daily workers, everything included, in fact, averaged £9 16s. 6d. last year. The weekly payment guaranteed by the Board—whether a man works or not—is £4 8s., but he must attend his control point every half-day to see if there is work for him to do. If he gets work on some occasions and not on others, he is credited with 5s. for each no-work turn. A registered man must be prepared to travel on a daily basis at the expense of the Board if he is wanted at a neighbouring port when there is no work for him at his own port. Period transfer is also arranged but only on a volunteer basis. The Board's aim is always to provide every man with a full week's work and every employer with all the labour he requires. That is the ideal but because the volume of work is erratic, the ideal is hard to achieve. Under-employment last year averaged 6% and this year the Board is budgeting on a

basis of 8.3%, but the figure to date has been heavier than that.

You must understand that the orderly arrangements of the Labour Scheme, which have conferred great benefits upon the work people, replaced very different conditions. Before the war, there were no guarantees, the work was entirely casual and there were more than 130,000 men on the registers compared with about 80,000 to-day. Many of them seldom worked a full week—three or four days was quite the common thing.

I should add that the Labour Scheme is administered by a national board assisted by 25 local boards. The workpeople and the employers have equal representation on these governing bodies.

The Evidence.

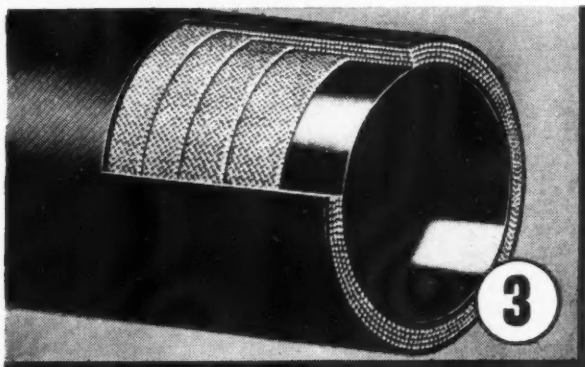
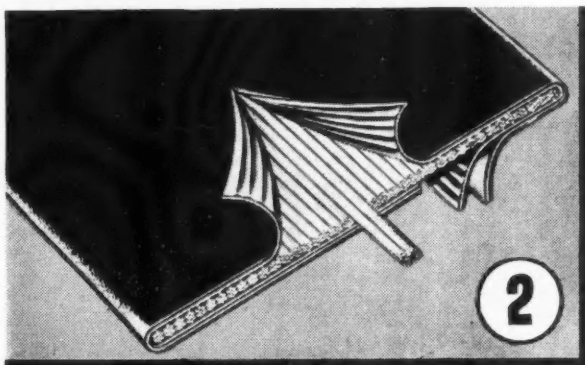
So much for the background. Now let us look again at our main proposition and then examine the evidence. It is said that ships are taking longer in port than they ought to do. Who says so? How do they prove it? What are their standards of comparison? Is the charge well founded? And is the complaint general or does it apply to some ports and not to others? It was said by the late Government in 1948 and they set up a working party to enquire into it and report. It is constantly being said by shipowners and by spokesmen on behalf of the Chamber of Shipping and the Liverpool Steamship Owners Association. It has been said by the Chambers of Commerce. It was again in the mind of the late Government in 1950 when they set up a working party to enquire into the mechanisation of cargo-handling. Last March it was the theme of an important debate in the House of Lords—most ably opened by Lord Winster, contributed to by eight other peers, notably Lord Waverley, and replied to by Lord Leathers, the co-ordinating Minister for Transport, Fuel and Power. It is much in the mind of the present Government for they have recently set up a Ports Efficiency Committee under Lord Llewellyn, to enquire into turn-round, especially at London and Liverpool.

How do they prove it and what are their standards of comparison? For the most part they compare the rate of turn-round to-day with the pre-war rate: and they often do that by pointing out that in pre-war days a given ship completed a certain number of round trips—say between London and Australia—in such-and-such a time, whilst in these post-war years she has been taking so many weeks longer to complete the same number of trips. Lord Winster and Lord Ammon said that one estimate was that a ship which used to take 17 days in port now takes 20 days. Again, it was said by the managing director of the Prince Line, addressing the Institution of Naval Architects in London in March, 1948, that in one of their trades, ships were losing 51 days at sea every year, as compared with pre-war, and that meant the loss of one complete round-trip per annum in that particular trade. In another trade, time in port, in a year, had increased from 161 days to 202 days—that is an increase of 25%. Lord Sempill spoke of certain ships spending nearly 60% longer in port than they did in 1937. Lord Winster mentioned a trade in which it now takes five ships to do the work formerly done by four ships: he added that with the increased speed now commonly built into ships, at great expense, it ought to be the other way round—four ought to be doing the work of five. Another standard of comparison was applied to short-sea traders—namely total time in port on this side against total time in port on the Continental side. Lord Winster spoke of a sample check which had been taken covering 74 such voyages: it showed that time in port on this side was twice as much as on the other side. Once more, you can try to judge the matter by looking at shipowners' expenses. The statement was made, in the debate, that before the war shipowners spent less than 40% out of their total outlay on port and handling charges and that it is now probably anything between 50 and 70%. A distinguished

*Lecture delivered at a week-end course on "Transport and the Public" at Ashridge, September 1952.

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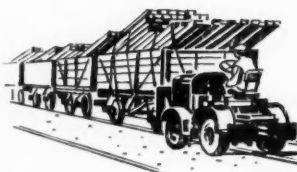
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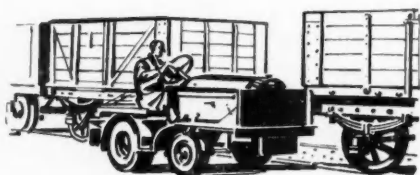
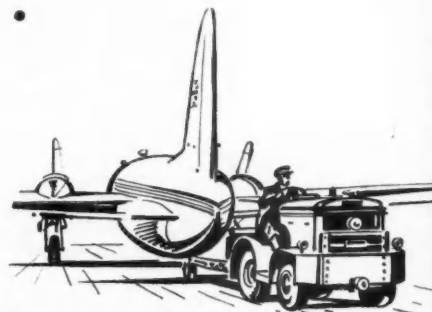
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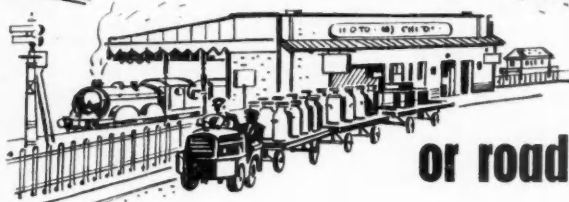
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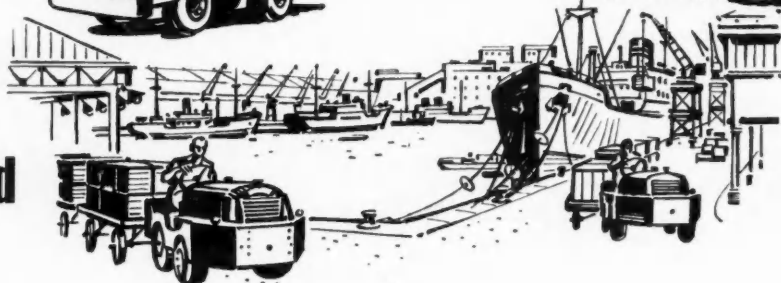
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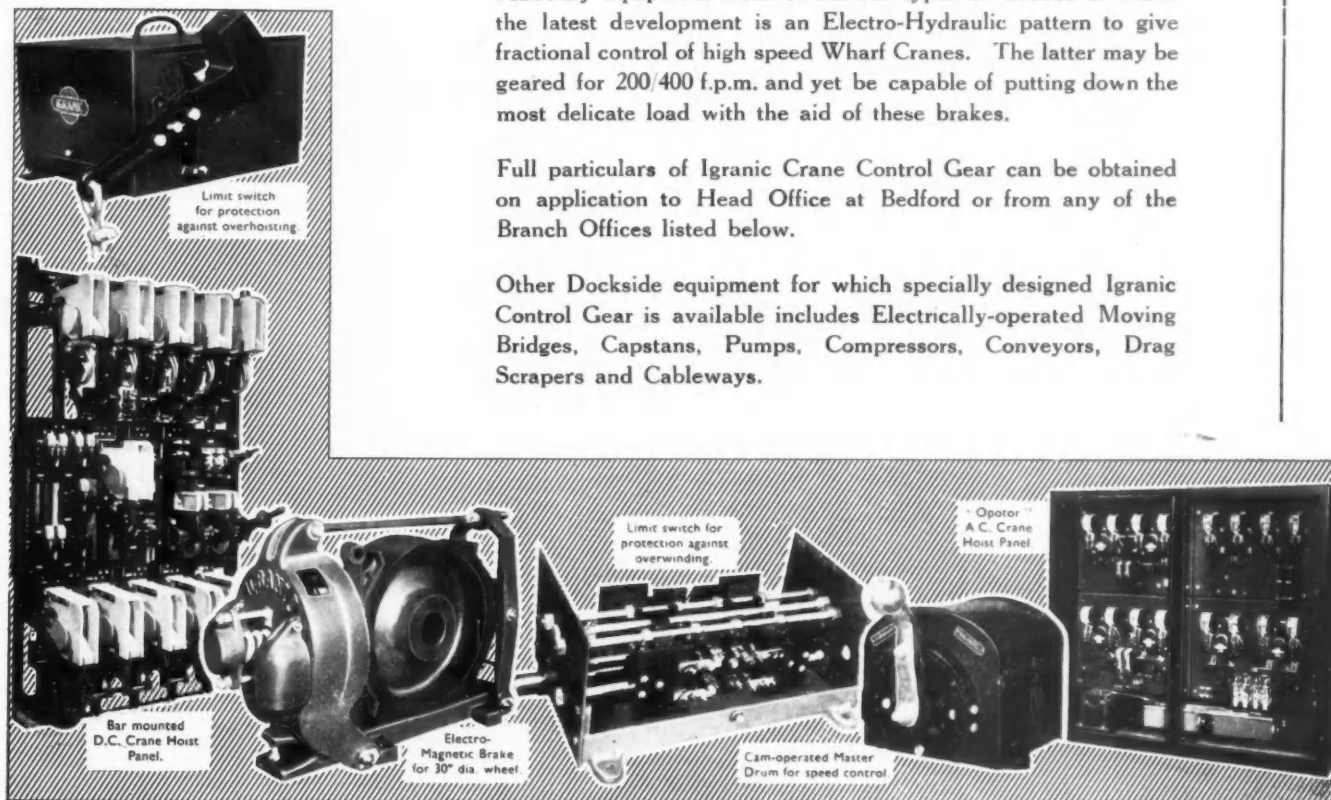
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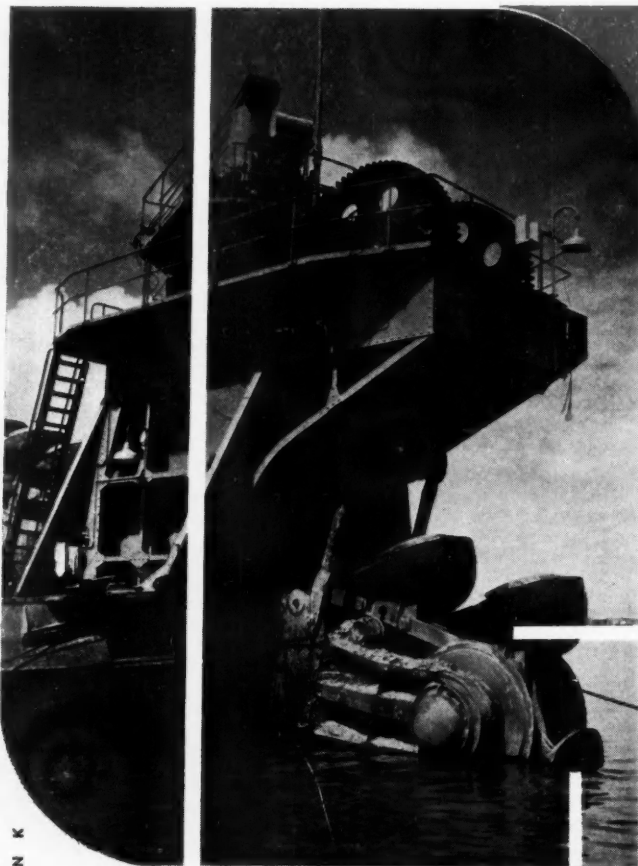
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Ports and Shipping Turn-Round—continued

Cardiff shipowner was quoted as having said that the average time of discharge of 6,000 tons of iron ore is now $5\frac{1}{2}$ days—and it ought to be two days or less.

It was urged that all this pushes up the cost of living and damages our overseas trade. An eminent Newcastle shipowner has said that three days' delay to a timber ship raises the cost of building timber by £1 per standard. Last February, the "New York Times" reported that delivery dates on British exports fall so far behind that customers in the dollar area transfer substantial orders to Western Europe.

So far, in this matter of the evidence, I have merely been quoting: nevertheless, the testimony comes from able and well-known men and we may be sure that they spoke of what they knew after carefully checking the facts. Nevertheless, I will now offer you a few simple factual statements relating to matters within my own experience. I have been associated with the management of the port of Sunderland for 18 years and I am able to say that during that period, complaints of delay to ships have been very rare indeed. On the contrary, from time to time, owners are good enough to write to their agents expressing appreciation for a good despatch. Let me hasten to say that our foreign trade is minute compared with the vast throughput of world terminals such as London and Liverpool. But again, I am in fairly constant touch with a number of the port managers of this country and I have not gathered the impression that, generally speaking, their ports are in a continuous condition of chronic congestion, with quays choked, warehouses bursting, ships held up and owners going frantic. I merely slip this in so that we may keep the picture in balance—and also to bring out this point, namely, although there can be no doubt that there is a turn-round problem, it is, very largely, a liner problem, and a mixed general cargo liner problem, and it is associated, in this country, almost exclusively with a very small number of great liner ports. And I cannot leave this question of the evidence without giving you some iron ore figures to place alongside the average figure already quoted. The statement made was that the average time of discharge of 6,000 tons iron ore is now five and a half days—and it ought to be about two days—that is, 3,000 tons a day. I have taken 13 typical iron ore cargoes discharged at Sunderland in recent months: the best discharge was a cargo of 3,336 tons in $12\frac{1}{2}$ hours and the average over the 12 ships was 2,729 tons a day. It is only fair to the workpeople and to the port authorities to try to look at all sides in these matters: and, for our purpose, it is desirable that you should know that, in every day that passes, a great deal of first-class work is done in the ports of this country.

The Causes (Organisation).

By organisation I mean anything whatever connected with the movement of seaborne traffic which is neither strictly a dock labour question nor an actual cargo-handling matter. First there is war damage in United Kingdom ports—more than £28 millions of it spread over 33 ports, and a great deal of it in London and Liverpool which are the two great foci of the general cargo liner trade. The work of reparation is going well but there is a lot to do and in the seven years since the war we have been hindered by financial crises, investment restrictions, materials shortage and labour shortages. Then there is the substantial increase in the general cargo side of our export trade. There is the switch in the character of our export trade: the coal export has been very nearly dried up for years so that the specialist coal-loading ports have been playing practically no part in foreign business and a lot of extra weight has fallen on the general cargo ports. There is the increase in the size of ships which means that the choice of berth tends to be more restricted than it used to be, the ships take longer to load, and as they are now loading full cargoes instead of part-cargoes (as before the war) they take longer still. On the inwards side in London, where more than half the traffic is barge-carried, you have lightermen working until seven o'clock and the destination wharves stopping at five. Beyond the port, you have a great many factories and receiving centres working a five-day week of 40 hours with the result that loaded barges and loaded rail-wagons sometimes have to stand. There have been a good many import controls and bulk buying arrangements and this sometimes tends to the arrival of very large quantities of stuff in

a short space of time instead of in many smaller quantities spread over a longer period. There has been a shortage of railway rolling stock, a shortage of warehouse accommodation and consequent congestion in transit sheds at the quayside. There have been shortages of cranes and other handling appliances and a consequent lag in modernising steamship berths to meet the new and heavier load upon them.

The Causes (labour).

Some part of the evil of slow turn-round is ascribable to weaknesses in the field of labour. I will mention some of them, but I wish to begin by saying that in my own experience the overwhelming majority of British dockworkers consists of hardworking, reliable men. The imperfections I shall mention apply to some people in some places on some occasions. From time to time, a small minority of dock workers tend to let down their mates and their own trade union leaders. There are restrictive practices and malpractices. Liners from our shores have had to leave cargo behind because of unofficial strikes and go-slow tactics. Efficient work is impaired by late starts, early finishes, the extension of recognised absences beyond the agreed time and unauthorised absences generally. The practice of "spelling" is met with—that is, a gang is made so large—by the men's insistence—that the men can take turns in leaving the work: jobs are extended needlessly into overtime at extra pay and Sunday working at double-pay: slings are underloaded in the hold so that 5-ton cranes are lifting a few hundredweights. The main body of decent workpeople sometimes allow a few trouble-makers to capture their local trade union organisation and to cause disputes for any reason or no reason. A gang held up temporarily will not move to another: hatch: gangs will not start work until fully made-up and will not mix to make full gangs. It is said by some that there are weaknesses in the dock labour scheme. It is suggested that the creation of the labour board has interposed an impersonal third party between the workpeople and the employers and that this breeds misunderstanding. It is believed by some people that the trade union members on the governing body are in an unhappy if not untenable position—they strive to be loyal to the men and faithful to the Board and because these duties must sometimes conflict, workmen who do not carry out their obligations under the scheme sometimes get away with it. Generally, whilst casual labour in the docks is dead, it is undoubtedly true that casual mentality is only dying.

The Causes (Cargo-Handling).

There is no doubt whatever that many operations in the docks are now performed by hand which could be partly or wholly mechanised. Unfortunately, there is also no doubt whatever that the dockworkers are suspicious of the introduction of machines and that, in consequence, employers are wary of sinking money in machines lest the money be wasted. The mechanisation of stevedoring is therefore lagging at a time when we are trying to cope with the greatest export trade in our history. There are instances of mechanised equipment being made available and not being used: or only being brought into use after long delays spent in protracted arguments about manning and rates of pay. It was said in the House of Lords debate that a Liverpool firm spent £6,000 on six fork-lift trucks and they lay idle for six months. It was also said that the Port of London Authority spent £150,000 on a new grain elevator, and it lay idle for a very long time—the dockers complained because it worked too fast: eventually they agreed to work it at rates of pay which gave them the whole benefit therefore leaving the cost to the port authority and the necessary charge to the importer as high as they were before. Machines reduce dirt, fatigue and accidents and raise the status of the workers: but in the docks, generally speaking, the workpeople are suspicious and are afraid of losing their jobs. The employers have promised that there shall be no dismissals: they will be content to rely on the redeployment of labour, normal wastage and, if necessary, the adjustment of recruitment. The workpeople have said that they will discuss increased mechanisation together with the introduction of a pension scheme. The employers have replied that they will discuss a pension scheme on its own merits but not linked with mechanisation. There the matter sticks—or was sticking until

Ports and Shipping Turn-Round—continued

lately at any rate. Although the dockers are now on a guaranteed week, paid holidays and good rates of pay, they are slow to forget the old days of casual labour and under-employment. Lord Sempill pointed out that in 1910 it took 104 man-weeks to produce a motor car and that last year it was being done in six man-weeks; and that between 1937 and 1952 the cost of handling a ton of coal out of a railway wagon into the bunker of a powerhouse had been cut from 6½d. to one farthing. We haven't gone that fast in the docks as yet—but the road is open.

The Cure (Organisation).

Before I describe the cure I must make two simple remarks. First, the treatment is already proceeding; and second, it will take some considerable time to complete it.

In the organisation sector, the requirements for swifter turn-round are partly in the port and partly beyond the port. In the ports we want the swift completion of our war damage repairs: many of us need more and better quay cranes: maintenance necessarily suffered during the war and some of us are only now getting rid of the arrears: and we must put down good paving wherever we can to facilitate the extended use of mobile appliances. Here again, I must not give you a wrong impression: a tremendous amount has been accomplished and there are many improvement schemes now going forward. At Liverpool, by the end of last year, two miles of new transit sheds had been constructed, many more were on the way, work is well advanced on a major reconstruction scheme at the Canada, Brocklebank and Langton Docks, and an imposing new iron ore berth is arising at Birkenhead: London is getting on with a vast programme of new sheds, warehouses, roads and quays: Hull has reconstructed quays, widened roads, installed new cranes and is tackling the work of rebuilding its Riverside Quay for the fruit and provision trades: at the Harlepoons there is an important development scheme in hand: the Tees is rapidly adding to its facilities for oil, chemicals and ore: Southampton has brought into use its magnificent new passenger terminal, a great dredging programme has been completed and an immense new oil terminal has been constructed at Fawley: other great new oil terminals have been sited at Manchester and on the Thames: the Tyne is improving its ore-discharging and coal-loading facilities, a great new drydock is going forward and a good start has been made with the introduction of fork-lift trucks for cargo-handling: at Sunderland, quays have been rebuilt, the river widened, land reclaimed from the sea, craneage power improved and drydocks and shiprepairing facilities notably extended in capacity. These are only examples—the whole national programme makes a most encouraging story.

Beyond the port confines, the requirements for better turn-round are (1) efficient co-ordination by the port authority with the on-carrying transport arms—namely rail, road, barge and coastwise carrier: (2) continuous co-operation by the port authority with steamship companies and traders—especially in the matter of the spacing of arrivals and the allocation of ships to ports: and (3) the fullest possible study, in close association with importers and exporters, including Government Departments, at home and abroad, of such matters as the packing and marking of goods, and the size, timing, spacing, warehousing, removal and reception of consignments.

The Cure (Labour).

In order to solve the problem of labour in the ports, the following requirements are necessary (1) the highly efficient machinery of the National Joint Council for the Port Industry must be universally respected and fully and continuously utilised—at the top level in London, in the provincial areas and in the individual ports (2) in spite of the inevitable arguments and different angles of approach, there must be developed and maintained a complete mutual respect and trust as between the dock workers' trade unions on the one hand and the port employers' organisations on the other (3) the leaders of the joint industrial organisation, from the supreme central Council down to the smallest sectional sub-committee in an outlying port, must all be men of unquestioned loyalty—first to their country, second to their colleagues on both sides of the table, and third to the negotiated agreements which alone clothe them with power (4) the National Dock Labour

Scheme must be objectively and impartially examined in order to ascertain whether the alleged weaknesses do, in fact, exist, and, if so, to recommend desirable improvements and (5) the odd few, whoever they may be, who allow or incite unconstitutional action, in defiance of freely-negotiated agreements, must be dealt with appropriately, promptly and fearlessly.

I am very well aware that those five suggestions contain nothing new. I also know that a number of the best men in the port industry, on both sides, have been patiently working along these very lines for a number of years and are still pegging away. Nevertheless, that is the only sure road to industrial peace in the docks. There is no other.

The Cure (Cargo-Handling).

It is very plain that by raising the speed of cargo-handling we shall do much towards improving the turn-round of ships. It is equally plain that increased mechanisation is the key to the problem and that, in this matter, the cargo-handling industry has lagged behind many others. The machines, the inventions, the new methods and the new ideas are available and are mounting up every month. They include the fork-lift truck combined with the highest practical development of the palletisation of cargo; the reduction of the man-handling of cargo in the holds by the use of cranes, power-shovels and mobile lifting machines which can work inboard; developments in the design of ships to give greater freedom for the use of cargo-handling machines in the hold; the extended use of trains of tractor-trucks to reduce manual carrying and hand-trucking on the quayside; newly-designed mobile cargo cranes to supplement the conventional and heavier portal quay cranes; faster and more powerful pneumatic elevators to handle bulk grain; belt conveyor plant in highly adaptable units and sections; and bulk ore discharging plant which completely mechanises the whole operation from ship's hold through shore bunkers into specially-designed rail wagons which are themselves mechanically discharged at the receiving end and then turned round immediately to go back to the ship.

By using such machines and methods as these, and the many more that are coming along and will come along, the task of cargo-handling will be lightened, transformed and immeasurably speeded up. I have already mentioned that their introduction at United Kingdom ports is proceeding very slowly. The workpeople fear unemployment and tend to be suspicious: the employers fear wasteful expenditure and tend to proceed warily. The only hope lies with the National Joint Council for the Port Industry and the National Dock Labour Board. Both parties are earnestly seeking to clear the road. It will be done by joint consultation, by infinite patience, by education, by the development of welfare schemes, by straight talk and honest dealing, and by the gradual removal of groundless fears. In other words, the technological problem is largely solved—the psychological remains, but it is being tackled and will undoubtedly be settled, in the docks industry just as on the farm, in the textile industries, in the mines and in transport.

Conclusion.

Finally, let me repeat that none of those requirements are new discoveries. Every day thousands of trained men, in the ports and beyond the ports, all over the world, are devoting their working lives to the task of trying to fulfil these very requirements. There are unending and everflowing streams of documentation pouring through the post, hours of telephoning, thousands of miles of journeyings—all aimed at getting the world's goods moved smartly, and in the right order, and in the state, and at the right time, from the point of origin down to the docks, through the docks into the ship, in the ship across the ocean, in the ship alongside a good berth all ready and waiting, out of the ship and through the docks, and from the docks to the place where the stuff is wanted. That is the work of steamship agents, forwarding agents, the commercial departments of port authorities, railway companies, road hauliers, lighterage contractors, the transport executives of industrial undertakings, buying organisations, sales managers, clearing houses charterers and booking agents. Apart from the men at work, who do their jobs as best they can and are always aiming at the maximum degree of co-operation with everybody else con-

(concluded on page 270)

Coaling Installation at Aberdeen

Principal Features of New Bunkering Facilities

An interesting coal discharging and bunkering Installation was erected at Aberdeen in 1951 and having just completed a year's operations most satisfactorily, it is appropriate to place on record some of the principal features.

The primary purpose of the scheme has been to secure a reduction in the handling costs of coal bunkers required for the Fishing Fleet at Aberdeen. Coal supplies for this purpose are almost entirely sea-borne and this had hitherto been discharged by ships' derricks on to screening hoppers, bagged, and transported to coal store by lorry. Thereafter it was transported, still in bags, as required, to trawlers where it was poured down chutes from the quayside — a lengthy and expensive process developed in the earliest stages of the Fishing Industry when mechanical handling was relatively unknown.

Owing to site difficulties an ideal scheme was impossible since it was necessary to combine the discharging of colliers and some bunkering of trawlers, etc. from the same quay so that the maximum efficiency of mechanisation has not been achieved although the performance is well within the requirements of the users. A better layout however, is already envisaged on a site which may be developed in the future under a long-term plan.

Nevertheless, results so far have amply justified the provision of the installation whose general character can be seen from the photographs and the layout plan accompanying this article.

The coaling berth consists of a quay 400-ft. long and an existing timber jetty 100-ft. long strengthened and converted to support conveying and bunkering equipment. The quay is constructed as a mass concrete superstructure carried in Larssen steel sheet piling tied back to a continuous concrete anchor wall set about 56-ft. back from the face. Special cylinder foundations were sunk to support a large 200-ton coal hopper at the root of the jetty and concrete walls to form the boundary of the coal compound were constructed, the whole of this Civil Engineering work being carried out by Messrs. W. J. Anderson, Contractors, Aberdeen at a cost of £52,650. The planning and co-ordinating of the work was carried out by Mr. John Anderson, M.I.C.E., M.I.Struct.E., M.Inst.T., Chief Engineer to the Aberdeen Harbour Commissioners.

Installation.

The Installation itself consists primarily of a coal compound or charged from colliers by large grabbing cranes and a hopper and

conveyor system for the distribution of coal reclaimed from the reservoir capable of storing 5,000 tons of run-of-mine coal discompound to specially designed conveyors and shoots. Coal may, of course, be discharged direct from collier to hoppers for bunkering so that no intermediate handling is required and in practice about 30 per cent. of the total discharge goes thus direct from collier to trawler.

The operating speeds designed for in both cranes and individual feeders and conveyors is 150 tons per hour whilst the main conveyor which can be charged from three feeders is capable of handling coal at the rate of 450 tons per hour. All coal passing through the feeders has to negotiate steel grids 12-in. square mesh which screens the run-of-mine coal to a suitable size for negotiating the bifurcated chutes without blockages. The chutes are designed with two branches to span the bridge works of a trawler so that coal may be sent to port or starboard hatches by merely operating a control flap valve.

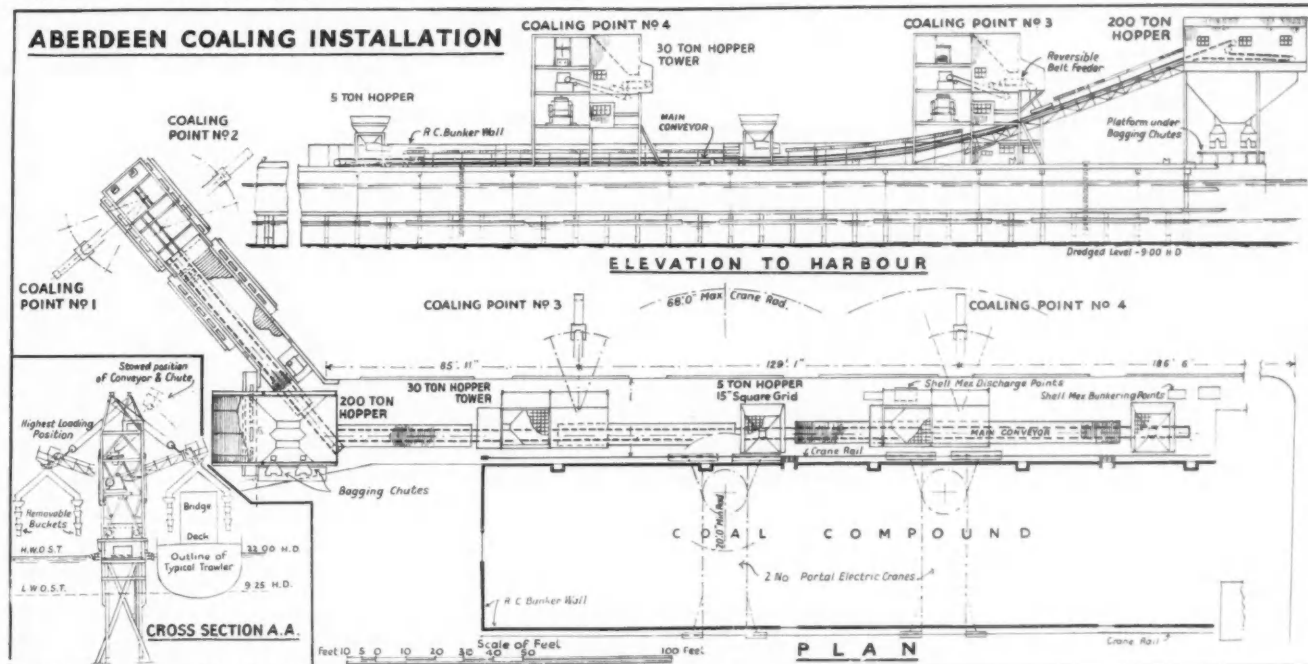
All coal sold for bunkers is passed over suitable continuous weigh-gear fitted to sections of the conveyors leading to the chutes, and records are thus made of the tonnage going out to each vessel. Weights of coal discharged can also be recorded through the use of special weighing machines on the cranes.

Cranes.

The function of the cranes is exacting. There are two of them discharging colliers, or reclaiming from the compound according to requirements and they have been designed to command both aspects of the work without themselves being seriously in the way. They are travelling portal type cranes whose legs completely span the coal compound at a height sufficient to clear coal dumped to a height of 20-ft. capable of depositing or grabbing at any point on the compound whilst also comfortably placed to discharge colliers at the quayside. They are, therefore, the key equipment of the installation. Designed and built by Messrs. Stothert and Pitt to the general specification of the harbour engineer they are electrically-operated 7-ton grabbing cranes with level-luffing jibs with the typical well-known balanced cantilever design operating at from 20-ft. to 68-ft. radius.

All motors were supplied by Messrs. Bruce, Peebles and Co., Ltd. and electrics by Messrs. Igran Electric Co., Ltd.

Rails are set at 60-ft. centres and the bogies are four-wheel



Coaling Installation at Aberdeen—continued

type placed 22-ft. crs. on seaward side and two-wheel type on landward side, also at 22-ft. crs.

The specified grabbing output with $3\frac{1}{4}$ tons capacity grabs was 150 tons per hour and the following general particulars may be of interest:

- 7 Tons at 68-ft. radius. Minimum radius 20-ft.
- Hoist Speeds—7 tons at 200-ft./min.
- Slew Speeds $1\frac{1}{2}$ Rev./min. $22\frac{1}{2}$ B.H.P. at 715 r.p.m.
- Luff Speeds 120-ft./min. 15 B.H.P. at 715 r.p.m.
- Travel Speeds 50-ft./min. $2/20$ B.H.P. at 715 r.p.m.

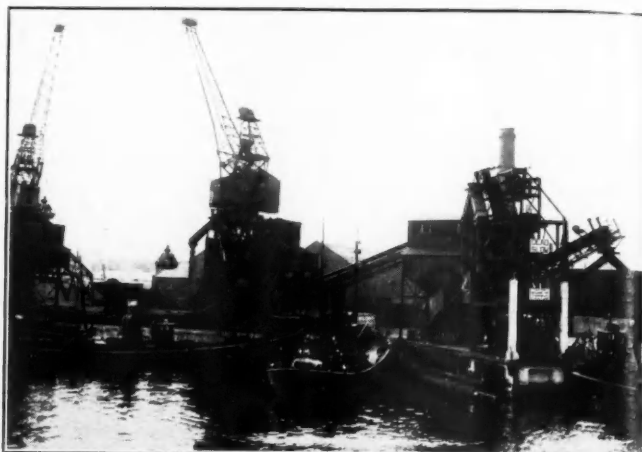
The cranes are fitted with hydraulic weighgear of $4\frac{1}{2}$ -ton capacity as designed for cranes by Messrs. Cory of Erith, Kent. The weights are registered from the hoist rope passing over weighing sheaves in the apex of the crane frame to the master cylinder which transmits the varying pressures through piping to the indicator machinery in the cabin, consisting of a steelyard, rack gradient and pinion operating the dial. The net weight for each lift is shown by dial indicator. An automatic recording totaliser is to be installed in due course.

Conveying and Bunkering Equipment.

The conveying equipment designed and constructed by Mitchell Engineering Company, Peterborough, to the general layout and specification of the harbour engineer, consists of hoppers receiving coal and conveyors carrying outgoing bunker coal over weighing equipment, thence to articulated conveyors and chutes which are manoeuvred into position over the trawler hatches. There are five hoppers in all, one of 200 tons capacity, two of 30 tons capacity and two 5 tons feeder hoppers.

The 200 ton hopper serves two bunkering points Nos. 1 and 2, each capable of loading at the rate of 150 tons per hour at a jetty situated at the extreme west end of the installation site. It forms a reservoir of coal reclaimed from the coal compound or discharged direct from colliers, capable of meeting the peak requirements for considerable periods without the direct operation of the cranes. The main conveyor belt which is 3-ft. wide runs the full length of the quay, is designed to feed this tower at the rate of 450 tons per hour (speed 450-ft./min.) although normally operated at an output speed of 300 tons per hour. This belt is fed by two small feeder 5-ton hoppers each with an output of 150 tons per hour, and there is also an alternative feed, when necessary, from one of the 30-ton hoppers No. 3. The feeders are operated by jiggering trays under the hopper discharge openings, the jigger strokes being 9-in. long.

The 30-ton hoppers are self-contained bunkering points Nos. 3 and 4 designed for the smaller bunker requirements of trawlers operating in home waters. They can also be used for larger trawlers, but they require the continuous service of cranes to do this. They have the same system of articulated luffing and slewing conveyor belts and chutes as already described in connection with the 200-ton hopper. They are designed to luff in, to be clear



General view of trawlers bunkering.

of the quay line by 2-ft. and to give an operating range above and below horizontal of 16-ft. at the chutes corresponding to 18° inclination on the conveyors. The slewing range is about 20-ft. overall so that there is never any need to move vessels once they have been positioned approximately to suit the particular arrangement of bunker hatches.

The operation of the bunkering points is automatically controlled to give sequence stopping and starting of all the elements, giving complete flexibility of control. The units can be stopped and started in the quay control cabins overlooking the vessel, at quay level manual switches or on board vessel by remote controls if required.

The control gear is designed and supplied by the Dalyte Electrical Company, the motors by Laurence Scott and Electromotors and the gears by Messrs. David Brown and Sons.

The weigh-gear on the bunkering conveyors is of the continuous type manufactured by Adequate Weighers, Ltd. of Sutton. The machine consists of a set of epicyclic gears chain driven from the conveyor belt and operating in turn a system of related parallel and tapered rollers and ball whose speed represents the different loads passing over the belt which are recorded on a totaliser.

All weighing equipment is set to Board of Trade standards and certified. The weights are recorded on two dials, one for individual bulk weights and the other giving a continuous record at the machines, but arrangements are being made for these to be remote recorded at the Installation foreman.

The cost of the installation, including cranes, hoppers, conveyors and chutes was £113,550.

Performance.

The Installation is giving complete satisfaction and has amply justified its purpose in the reduction of coal handling costs and in comfortably meeting the requirements of trawlers and commercial vessels requiring bunker coal at Aberdeen.

The peak demands made during the first year's operations have been handled without difficulty within the normal working day.

The following figures are indicative of the capacity of the Installation based on actual performance:

- (1) Bunkered during the year February, 1951 to January, 1952—3,300 trawlers.
- (2) Tonnage handled during February, 1951 to January, 1952—168,000 tons.
- (3) Commercial vessels—24 vessels took 2,400 tons.
- (4) Best week—3,933 tons to 88 vessels.
- (5) Best day—1,257 tons to 25 vessels (representing 6,913 tons per week of $5\frac{1}{2}$ days for 137 vessels).

There has already been a substantial saving achieved in operational time required for coaling trawlers as well as in handling costs and further improvements of technique and auxiliary equipment is under consideration which it is hoped may lead to even better results in the future.



Looking along quayside from the east.

Pallets and the Port Industry

(2) The Unit Load Method of Goods Handling

By E. S. TOOTH

THROUGHOUT the world, the post-war era has been characterised by a drive to introduce into industry of all kinds, new types of mechanical handling appliances. Among the most revolutionary of these are the fork lift truck and the pallet truck, two machines which so quickly proved their worth in factory work that their advocates assumed that their introduction into port operating work would be just as speedy. Experience has shown this assumption to be incorrect; but the difficulties encountered have not been primarily connected with the machines, they have revolved round what use can be made of pallets.

Pallets which ports have to handle fall into two categories: (1) those used as items of port operating equipment and (2) those which form "permanent" parts of palletised unit loads of goods.

The using of pallets as cargo-handling equipment (heading (1) above) was dealt with in the December, 1952, issue of this Journal under the title "The Pallet as a Handling Tool." There is little to add to that article at this stage. A satisfactory means of handling exports through the docks by employing fork lift trucks and pallet-landing boards has been evolved by the Port of London Authority and is working well. Experiments on similar lines are being made with the handling of green fruit and other import commodities and there is no doubt that a system of working will be evolved, incorporating the use of the same types of handling equipment, which will enable import goods to be landed from ship, piled in shed and subsequently delivered, with more speed and much less arduous labour than result from current methods.

The "Throughout Movement" Method.

It is in the sphere of the method of transporting goods between country and country, which involves building them into unit loads on pallets at or near the point of production—sometimes called the "throughout movement" method—(heading (2)) that the future is so intriguing and so difficult to forecast. At present, practically the only palletised traffic being passed through British ports is a small percentage of the short sea traffic.

The theory of the "throughout movement" method is simple. It is that goods for export should be piled and strapped on pallets at point of production or at least when being prepared for export. They can then travel to overland or overseas destination as separate and complete units, the pallets being either "returnable" or "expendable." Besides the saving of arduous labour, the potential benefits of the method include (1) cheaper handling costs, (2) speedier despatch, (3) reduced damage and pilferage risks, (4) a saving (by high piling) of shed and warehouse space, and (5) (it is held in some quarters) lower shipping freight rates. It is extremely important, when considering these benefits as inducements to palletise, to note that they accrue to different interests. The theory assumes (if item (5) is included) that stowage space lost in ship (i.e. that occupied by the pallets) will be more than offset by lower stevedoring costs and by time saved at loading and discharge.

Its Implications.

Thus, although the theory is simple, its implications are complicated. Before adopting the method, the shipper must become convinced of the value of the benefits which will accrue to himself. If, besides being the shipper, he is also the manufacturer of the goods, he may have to adapt his production machinery. In either case, he will have to acquire not only pallets but probably pallet-handling machines as well.

Immediately the palletised unit loads leave the factory, a chain of interests becomes vitally concerned in handling them. These include cartage and railway contractors, the organisation responsible for accepting the goods into dock transit shed and tendering them to the ship, and the ship loading agent—and also, it must be remembered, the counterparts of all these interests in the country of destination. This implies the need not only to provide

suitable machines at each point of handling, but often also to adapt premises. If the best use of the machines is to be made, doorways may have to be enlarged, floor surfaces improved, approaches altered.

It will be seen that if large scale transportation of goods in palletised unit loads between country and country is to become a reality, a degree of standardisation of machines and pallets is necessary conjointly in the exporting and importing countries. This essential need involves makers of pallets and pallet-handling machines, manufacturers of export goods, shippers, road and rail haulage contractors, dock and harbour authorities, master stevedores and other labour contractors, cargo superintendents (who must take an accurate tally of all goods shipped), customs' authorities (who must "clear" all parcels of exports—often by examination) and shipowners (who will be concerned with speeds of loading and discharge and also most certainly with possible loss of freight space).

It is because the practical problem is so complex and the potential benefits so widely distributed and so difficult to assess, that the development of palletised traffic between country and country is slow and certainly as far as Great Britain is concerned, in cross-ocean trade has virtually not yet begun. The subject has been a contentious one for most of the post-war era.

Pallet Standardisation.

It is of vital interest, therefore, that an important step in the solution of the problem is at present being taken. Last month, a technical committee of the International Organisation for Standardisation, appointed to consider international standards for "Pallets for Unit Load Methods of Materials Handling," held its first meeting. After four years' preliminary work by the I.S.O., it was felt that there was adequate knowledge and sufficient interest and inducement for such a meeting to produce results. Moreover, the unit load method of handling had in recent years made such strides that in a number of countries the formulating of national standards was well advanced. It was obvious that, before too many final decisions were made nationally, international standards should be recommended, at least on the primary matters of the dimensions and design of flat pallets.

The meeting, which was held in London, was in effect, a three days' conference of delegations from Australia, Belgium, France, Germany, Netherlands, Norway, Sweden, Switzerland and the United Kingdom, the secretariat being provided by the British Standards Institution. The United Kingdom delegation included representatives of pallet manufacturers, handling machine manufacturers, shippers, road and rail transport, the port industry, shipping, the armed services and industry generally. A number of nations who were interested but unable to attend—Denmark, Finland, Italy, Mexico, New Zealand, Portugal and Spain—asked to be kept informed of the progress of the work. Several organisations sent observers, who, although not entitled to vote, contributed much of value to the discussions. These organisations included the Economic Commission for Europe, the International Cargo Handling Co-ordination Association, the International Container Bureau and the International Union of Railways.

At a luncheon at the Dorchester Hotel arranged to welcome the foreign delegations and the observers, Lord Waverley, speaking as President of the British Standards Institution, stressed the importance of the potential benefits of the extension of the unit load method of handling and wished the committee well in the difficult task which lay before it.

In international trade, four important aspects of pallets are size, design, strength and cost. Size is important because (a) pallets must carry economic loads and (b) they must be of such dimensions that they can be stowed quickly and without undue loss of space, particularly in transport vehicles. Design and strength must take into account (a) the need for pallets to be handled by different

Pallets and the Port Industry—continued

types of machines at home and abroad, and (b) the weight of the load they have to carry. Strength is also important in connection with the frequent need to stow several tiers high not only in shed and warehouse, but also in ship's hold, where special kinds of stresses and strains are imposed on the palletised unit loads by the motions of the ship at sea. Pallets must be cheap enough not to add appreciably to the initial cost of exports and it is in this sphere that consideration must be given by the shipper to the relative merits (for his particular traffic) of expendable and returnable pallets. It may be that when there is international traffic in palletised unit loads on a large scale, the receiver of the goods will often find a market for the pallets in his home country and will therefore be prepared to pay for them.

The materials of which pallets are made may affect three of the four factors mentioned—viz. design, strength and cost. Although returnable pallets are at present made mainly of timber or steel and expendable pallets of softwood or fibre-board, it is feasible that developments in international traffic in palletised unit loads will bring some changes in these materials of construction.

The standards which are taking shape as a result of this first international conference have been based mainly on the need for the pallet to carry an economic load (from the shipper's point of view) and on the necessity for the unit to be stowed economically in transport vehicle. Hence most time was spent by the conference in settling plan-sizes, although other factors, such as the distance between top and bottom decks and the height to underside of top deck were regarded as of utmost importance.

In determining the plan-sizes to be included in the recommendations, it was borne in mind (1) that it was not reasonable to expect any nation completely to revolutionise the design of its road and rail vehicles in the interests of the "throughout movement" method, (2) that ship loading and discharging agents can adapt their handling equipment to meet most exigencies, and (3) that no factor connected with stowing units in ship's hold is as important to pallet dimensions as the sizes of existing road and rail vehicles.

The "Stevedores" Pallet.

In connection with (2) and (3), it is of interest to note that some countries, the Netherlands, Norway and Sweden in particular, are employing what is commonly known as a "stevedores" pallet. This is a dock tool (somewhat like that described in the first of these two articles) which permits the lifting of an economic load by quay crane or ship's winch.

This pallet has a number of uses (1) it can be employed as a loading board, either for "loose" packages or for two palletised unit loads—in which case it is unloaded in the ship's hold and returned to the quay for re-use, (2) it can be used between port and port, being stowed loaded, in the ship's hold and returned, reloaded, from abroad, and (3) it can be used between sender and receiver as the base of a normal unit load of goods—provided it is suitable for all the transport vehicles concerned. "Stevedores" pallets are already being employed by the three countries mentioned for each of these purposes.

The pallet used in Scandinavia measures 48-in. x 64-in. and can therefore accommodate two "normal" pallets measuring 32-in. x 48-in.; that used in the Netherlands, measures 48-in. x 72-in., and can be loaded with two pallets 40-in. x 48-in., there being a 4-in. overhang at each end.

It should be mentioned here that at least during times when freight space in ocean-going vessels is at a premium, the stowing in holds of "stevedores" pallets also bearing other pallets, might only be acceptable to shipping companies if they received compensation for the cargo space taken up by the pallets.

In submitting their recommendations to the I.S.O. in connection with international standards for plan-sizes and other dimensions of "normal" pallets, the technical committee also agreed the desirability for an international standard for a "stevedores" pallet. Working parties will continue to do preparatory work on the remaining aspects of pallet-standardisation so that when there is next a full meeting of the technical committee, such matters as tolerances, nominal ratings, materials, testing and terminology and definitions can be dealt with.

Palletised Traffic in Cross-Ocean Trade.

However, despite the work so far done in this sphere both nationally and internationally, and despite the undoubted growth of the "throughout movement" method for internal trade and for certain short sea traffic, it is not possible to estimate when traffic in palletised unit loads will develop appreciably in ocean-going trade. In the short sea trade the savings of time effected at loading and discharging may be considerable when compared with a sea voyage of a few hours. When voyage times are measured in terms of weeks, however, the implications are different. The saving in time alone will by no means offset the loss of freight space and it may be that there will be no appreciable proportion of palletised units in ocean-going traffic until a new inducement appears.

The formulating of international standards for pallets may result in providing that inducement. The replacement of the repeated manual handling of the same individual packages (which may occur a dozen times before destination is reached) by the mechanical lifting of unit loads of a ton or more, might itself result in such dramatic savings of time and money at certain points of handling, as to provide the impetus for the quick extension of the "throughout movement" method.

If large-scale traffic in palletised unit loads does begin to develop, it will be a sure sign that the manufacturers, shippers and particularly road and rail transport contractors have begun to overcome their difficulties. What then will be the position in British ports—in a port like London, for instance?

It has already been described how the Port of London Authority has introduced a scheme embodying the use of pallets as tools to handle unpalletised goods—the use of "stevedores" pallet, in fact. All that will be needed will be a development of this method of handling. The need to introduce suitable mechanical appliances was borne in mind when planning new premises and reconstructing those damaged during the war. The modernisation of the port has been undertaken continuously. Adequate mobile cranes and Diesel-and battery-driven fork lift trucks will be available and a procedure is already in operation which overcomes the difficulties of tallying by cargo superintendents and the examination by Customs of palletised goods. Since any potential advantages must be made real, it is realised, too, that handling gear may have to be adapted to avoid delays in the sheds and at the ship's side and also to ensure that the 3-tons and 5-tons electric luffing cranes which line the Authority's quays will be lifting economic loads. The quick turn-round of ships is still of utmost importance and the British port industry, used as it is to having to meet new circumstances at a moment's notice, will undoubtedly be prepared to assist and to encourage the expansion of traffic in palletised unit loads.

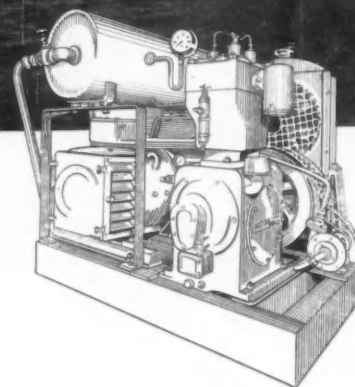
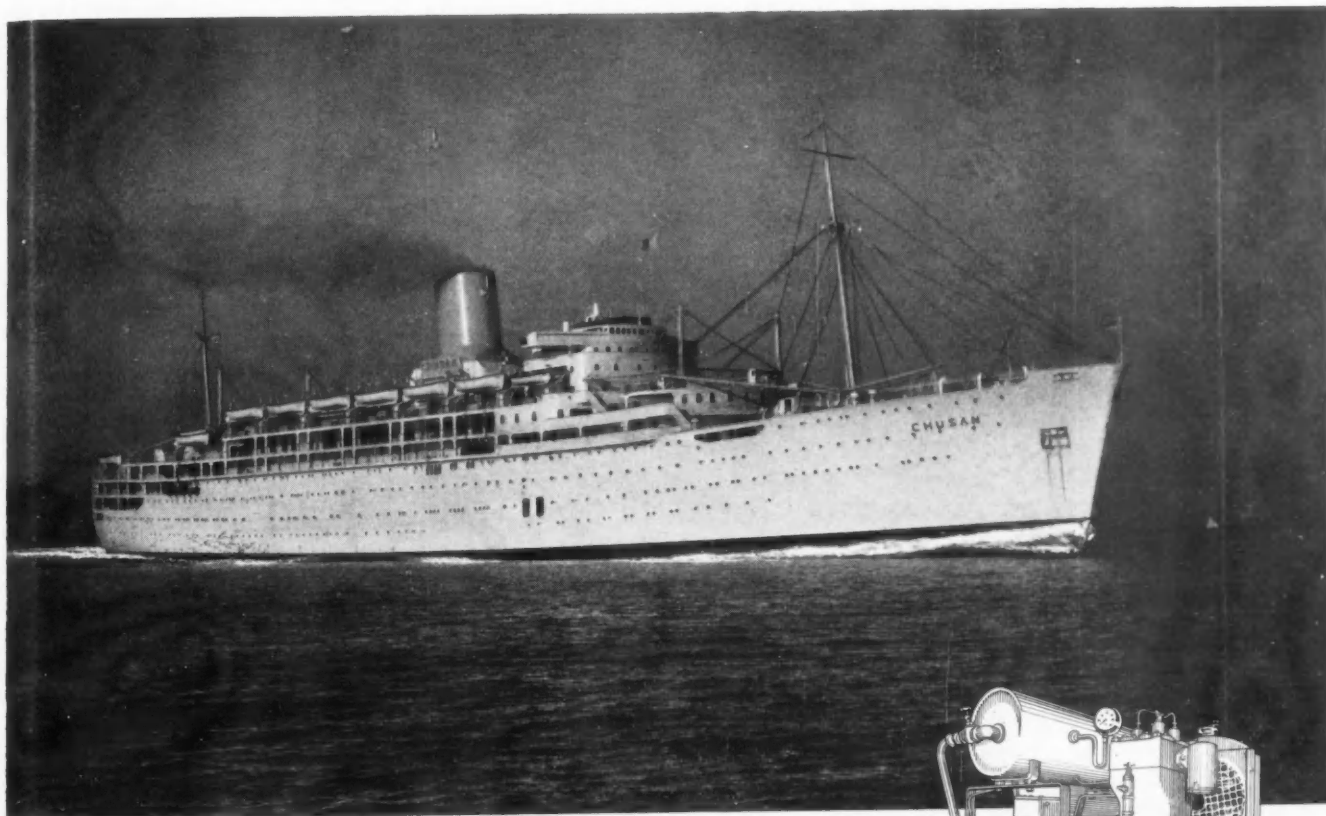
Port and Shipping Turn-Round

(concluded from page 266)

cerned, valuable contributions in the way of organised conferences, discussions and research come from bodies such as the technical committee of the National Association of Port Employers, the Chamber of Shipping of the United Kingdom, the Liverpool Steamship Owners' Association, the Institute of Transport, the Ministry of Transport, the Institution of Naval Architects, the International Association of Navigation Congresses, the Dock and Harbour Authorities' Association of the United Kingdom, the American Association of Port Authorities, and the International Cargo Handling Co-ordination Association. You will gather from that list that a great many persons are accustomed to devote some thought to various aspects of the subject we have been considering.

Well, Ladies and Gentlemen, I have tried to explain to you what this problem of turn-round amounts to and I have also endeavoured to set it against its proper background, to indicate the contributory causes and to suggest to you the main ways in which improvement must come. Thank you very much for the patient hearing which you have given me and I shall be very pleased to join you in the discussion which I expect you would now like to arrange.

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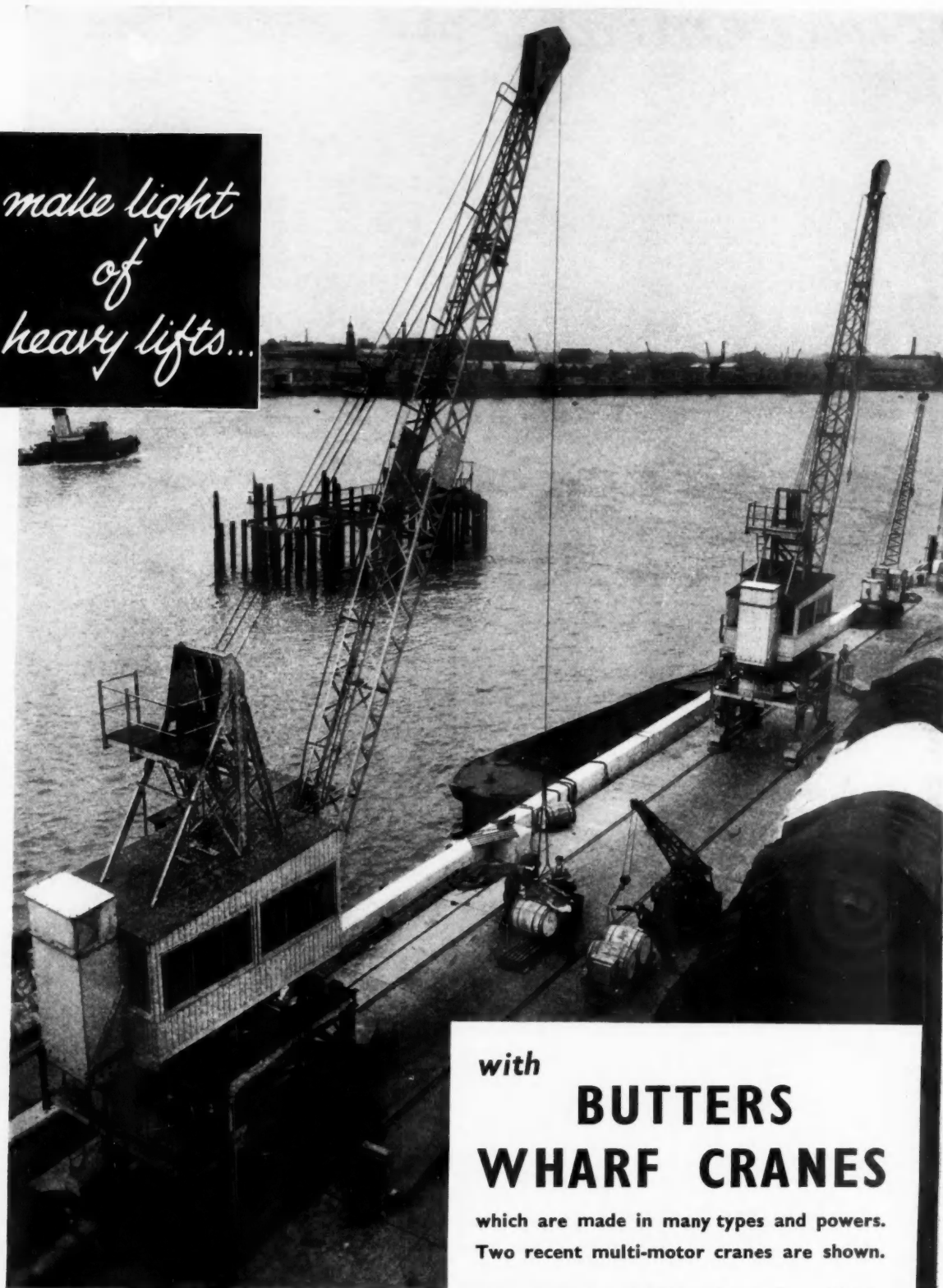
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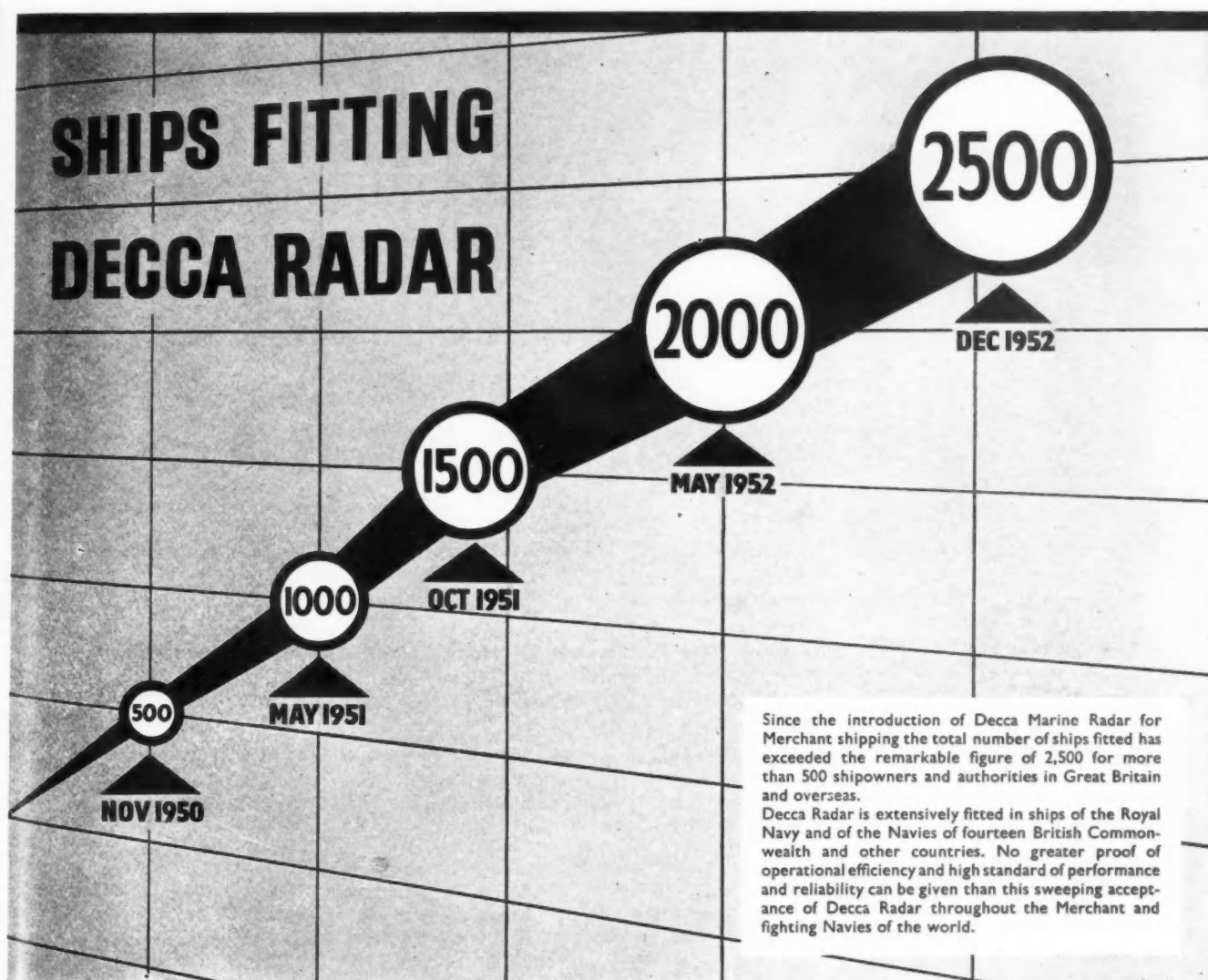
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Structural Timber for Dock Work

III. An Introduction to British Standard Code of Practice 112, "The Structural Use of Timber in Buildings"

By P. O. REECE, A.M.I.C.E., M.I.Strut.E., A.M.I.Mun.E.

THE introduction of the Bessemer and later the open-hearth processes towards the end of the 19th century opened the way to the production of cheap steel on a scale undreamt of by even the most visionary of the Victorian engineers who brought it about. Owing to practical limitations on the production and use of cast-iron, timber was still the first choice of the designer for all but the heaviest structures, but the new mild steel struck a blow from which timber has hardly yet recovered.

Steel at that time was very much more than a mere substitute for timber and cast-iron, it offered dazzling prospects to the engineer and made possible the erection of structures of unprecedented size, complexity and delicacy. The differences between the old and the new forms of construction were not merely differences of degree or size, but differences of kind, nevertheless they can mostly be attributed to two qualities of mild steel which were then new:

- (i) A high degree of uniformity in quality, enabling working stresses to be established with some degree of uniformity and precision.
- (ii) High working stresses in shear and bearing, enabling efficient joints to be made, thus introducing the element of continuity in structures and components.

Weight for weight timber is, on the whole, stronger than even modern steel, but its anisotropy, its variability and its low strength in horizontal shear would always have hindered the free development of the structural forms we now take for granted in modern structures. Technical development has continued fairly steadily through this century to overcome these inherent difficulties, but it has generally been pursued in the timber-producing countries where steel has been comparatively expensive and it is only in the last twenty years or so that the possibilities of timber as a modern structural material have received serious attention elsewhere.

Once the modern methods of scientific and industrial research had been applied to timber it was perhaps inevitable that development would take place along lines made familiar to us by the "modern" materials with the result that an up-to-date timber structure is now at least as efficient as its contemporaries of steel and concrete and aluminium and bears a much closer family resemblance to them than it does to its Victorian or earlier ancestors.

Most gradual processes require some external stimulus before the results will emerge to make an effective impact. During the past fifty years or so many hundreds of patents have been filed for improving techniques of timber construction but it required Pearl Harbour to test their effectiveness on a sufficient scale. When the United States came into the war she was faced with the problem of finding prodigious quantities of steel for armaments and at the same time had to produce materials for the factories, offices, shipyards, docks and transport necessary for the building-up of a war-time economy. More than half of the world's lumber is produced in Canada and the U.S.A. and it was natural that timber should be used to save steel. This presented timber with its grand opportunity and during the succeeding five years there was hardly a structural problem which was not tackled by American and Canadian engineers in timber—and tackled successfully.

British Practice

Although since 1939 Britain had suffered an enforced shortage of timber, the developments on the American Continent did not pass by unnoticed and, towards the end of the war when the

general codification of building practice was under review, it was decided to proceed with the preparation of a British Standard Code of Practice for the structural use of timber in building.

Preparatory work for this had been slight. Before the war the Forest Products Research Laboratory at Princes Risborough had started a research programme on the strength properties of Baltic redwood and whitewood, the two European timbers most commonly in use, and the London County Council had taken the results of this work into account, combining them with similar data from American and Canadian sources to provide the first rational bye-laws for design in timber.

In 1941 the British Standards Institution produced the first edition of "Grading Rules for Structural Timber" and in 1943 work was started on the draft Code of Practice. This was without precedent in Britain, no effort had previously been made to tackle the problems of timber in a comprehensive way, and the drafting committee had to start more or less from scratch. New research had to be initiated, foreign codes had to be studied and related to conditions in Britain, design procedure had to be elaborated and tested in practice.

The first published draft was circulated for comment to interested authorities not only in Great Britain but throughout the world. It was issued in 1947 and very shortly afterwards the drafting committee re-commenced its work, this time on the final document and with invaluable assistance derived from a voluminous mass of comment, suggestion and criticism. Further research was put in hand, and much of the original data were re-checked and re-examined. It is understood that by the time this article appears in print copies of the final Code will be on sale by the British Standards Institution, 24-28, Victoria Street, London, S.W.1.

In 1946 the Timber Development Association set up a special department to conduct research into the structural utilisation of timber. In close collaboration with the Forest Products Research Laboratory it undertook much of the research work involved by the preparation of the Code of Practice and in the succeeding six years it has promoted the construction of many large timber-framed structures designed in accordance with the Code provisions. This has provided the means for full-scale experiment, not only in design procedure but also in actual construction as witnessed by the illustrations accompanying this and the previous articles.

STRENGTH PROPERTIES

In general, the strength properties of timber are determined by (i) its density; (ii) its homogeneity and (iii) the type and duration of loading, moisture content and other conditions of service. Wood tissue is itself a complex substance and even within the same species it is subject to such a wide range of variations as to make an elaborate, rigorous mathematical analysis of strength properties impracticable for the ordinary purposes of design. In consequence the Code committee accepted the necessity for introducing a considerable measure of simplification to reduce the labour of design to a level comparable to that involved in other structural materials.

This can be achieved only by a general loss in economy; where a classification is broadened to include inferior species or qualities, it follows that permissible stresses must be reduced to a lower level, with the result that the average margin of safety is greater than would otherwise be considered necessary.

The first step in the process of simplification was taken by the classification into two broad groups of the structural softwoods currently available in the United Kingdom. This classification

Structural Timber for Dock Work—continued

may be assumed to take into account the effects of density and is shown in Table 1.

Table 1.
Classification of Structural Softwoods

Group	Standard Name	Botanical Species	Minimum weight per cubic ft. at 22 per cent moisture content lbs.
I	DOUGLAS FIR (COAST)	<i>Pseudotsuga taxifolia</i> Brit.	27
	LONGLEAF PITCH PINE	Principally <i>Pinus palustris</i> Mill	32
	SHORTLEAF PITCH PINE		27
		<i>Pinus echinata</i> Mill	
II	CANADIAN SPRUCE	Principally <i>Picea glauca</i> Voss	22
	EUROPEAN LARCH	<i>Larix decidua</i> Mill	27
	REDWOOD	<i>Pinus sylvestris</i> L.	26
	WHITEWOOD	<i>Picea abies</i> Karst.	21
	WESTERN HEMLOCK	<i>Tsuga heterophylla</i> Sarg	23

A simple classification for structural hardwoods has not yet been achieved and it is recommended that when embarking upon de-



Storage Building 180-ft. long, 145-ft. wide, consisting of 87-ft. 6-in. central clear span and two side bays each 28-ft. 9-in. wide. Rigid frame construction. View from line of internal supports across central span.

sign in hardwoods, designers should refer to the Forest Products Research Laboratory or to the Timber Development Association for advice.

The homogeneity of timber is disturbed by natural gross features such as knots, shakes, splits sloping grain, wane and growth rings. Here the Code committee had two extreme courses open to it; it could arbitrarily fix working stresses and then calculate the maximum permissible dimensions of gross features, or it could fix limits for the gross features such as would involve only a reasonable minimum of rejections from the commercially available qualities, and then compute appropriate working stresses. In fact, it became necessary to achieve a compromise as, on the one hand it was felt that any radical departure from the qualities of timber in general usage would cause undue dislocation in the building industry, while, on the other hand the effect of the earlier British Standards on grading, and the L.C.C. bye-laws had familiarised many authorities with standard working stresses such as 800 and 1,200 lbs. per sq. in.

To avoid confusion, the British Standards 940, Parts I and II dealing with the grading of structural timber, were withdrawn and replaced by B.S. 1860—"Structural softwood, measurement of characteristics affecting strength." This enabled a great deal of highly detailed matter to be omitted from the Code, which contains merely the schedule of gross features permitted in the two groups of structural softwoods. These are shown in Table 2.

Table 2.
Permissible Gross Features

Nominal width of surface	Knots on edge or at centre line of face of beam or on any surface of a tension member	*Margin knots or knots on any surface of compression member or member subject to combined flexure and compression	Shakes, Checks and splits
1"	1"	1"	1"
1 1/2"	1 1/2"	1 1/2"	1 1/2"
2"	2"	2"	2"
2 1/2"	2 1/2"	2 1/2"	2 1/2"
3"	3"	3"	3"
4"	4"	4"	4"
5"	5"	5"	5"
6"	6"	6"	6"
7"	7"	7"	7"
8"	8"	8"	8"
9"	9"	9"	9"
10"	10"	10"	10"
11"	11"	11"	11"
12"	12"	12"	12"

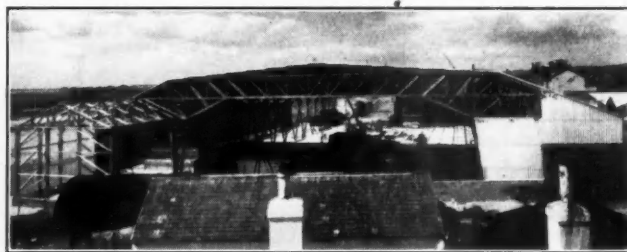
Slope of grain. The slope of grain should not be steeper than 1 in 8 for beams and for compression members not more than 4" thick, and 1 in 11 for compression members over 4" thick.

Wane. The reduction due to wane in the width of a surface at any point should not exceed 1/4" for beams and for compression members not more than 4" thick and 1/6" for compression members over 4" thick.

Rate of growth. There should be not less than 6 rings per inch in Group I timbers and not less than 4 rings per inch in Group II timbers.

*Margin Knot. A knot, appearing on the face outside the middle half of the depth of the face, near to, or breaking through, an edge.

In dealing with permissible working stresses it was found necessary to introduce two additional terms—the "basic" stress, and the "modification factor"—to take into account variations due



External view of Storage Building described on left.

to the type and duration of loading and other conditions to which timber may be subjected in service and which may have an effect on its strength properties. This may be illustrated by reference to the increased stresses permitted in wind-resisting structures. Timber will safely sustain for short periods of time, loads about twice as great as would be sufficient to cause failure if maintained for periods of years. Consequently, if f_b be the safe working stress for a permanent load and K_1 be the "modification factor" for wind loading, then the permissible wind stress will be $K_1 f_b$ (where, in the case quoted $K_1 = 1.50$).

By definition the "basic" stress is the stress which can be permanently sustained by a solid timber beam, tie or short column of uniform rectangular section, loaded in a direction parallel to one of its orthogonal axes; while a permissible working stress is the product of the basic stress and the appropriate modification factor. Where there is no appropriate modification factor, the permissible stress is to be taken as equal to the basic stress.

Within these definitions, for the groups of timber classified in Table 1 and having gross features in accordance with Table 2, the basic stresses are given as in Table 3.

Structural Timber for Dock Work—continued

Table 3.
Basic Stresses (lb. per sq. in.)

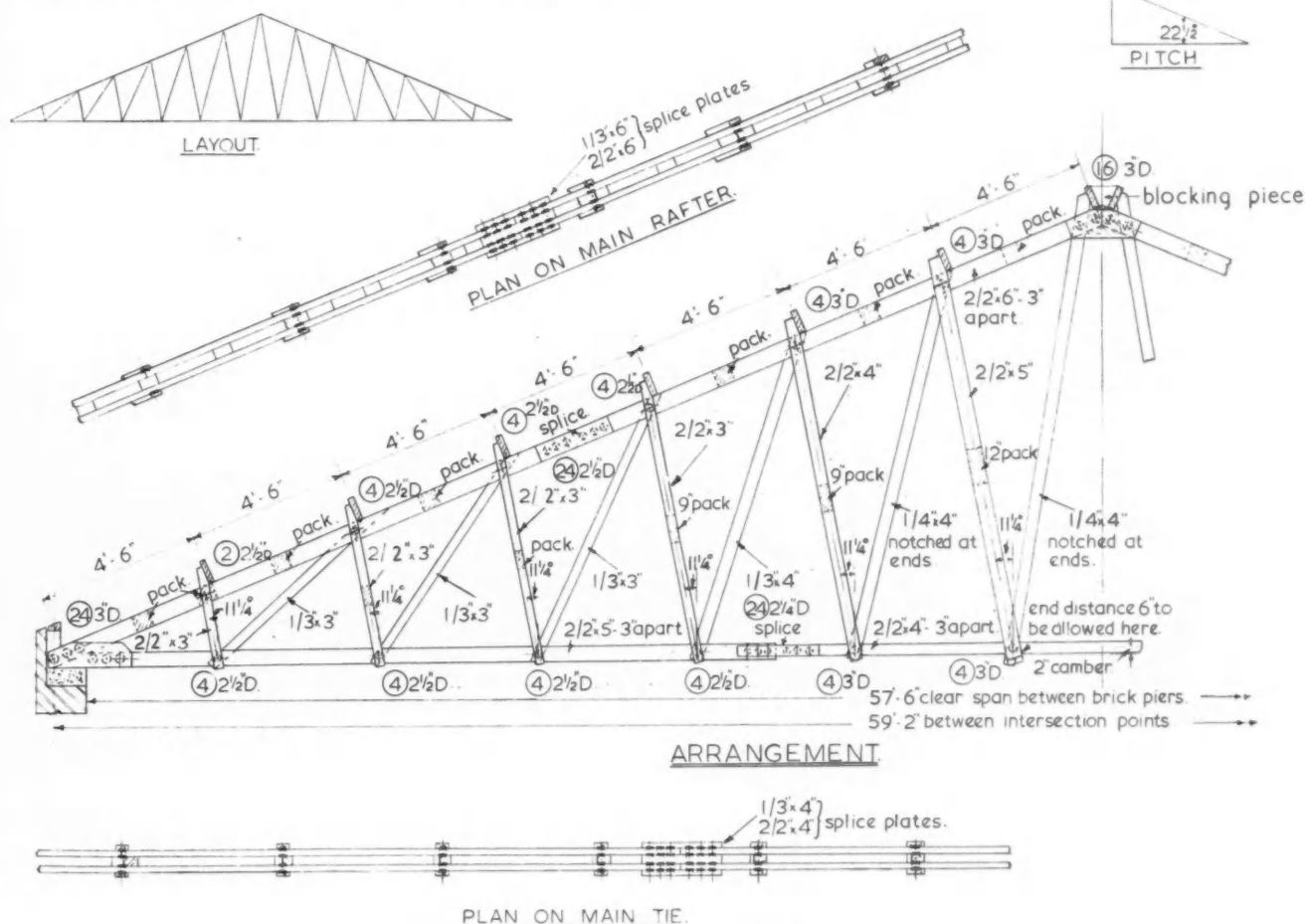
Group	Flexure and compression parallel to grain	Compression perpendicular to grain	Tension	Shear parallel to grain	Modulus of Elasticity	
					Mean	Minimum
I	1,000	350	1,500	100	1,600,000	1,000,000
II	800	250	1,200	100	1,200,000	750,000

In fixing these basic stresses, reference has been made to what might be termed the "statistical minimum" values displayed by a large number of samples tested. They are therefore related to the poorest specimens in a batch. Where a number of members or components can be considered as acting together, the strength values displayed will approach the mean value for the batch and will be higher than the minimum. It is provided in the Code that the mean value of modulus of elasticity given in Table 3 may be used for rafters and floor joints considered to be acting together,

to act during the life of a structure. The results of this work are incorporated in Table 4 in the values for the modification factor K_1 by which the basic stresses in flexure and tension may be multiplied under the different conditions of loading.

Table 4.
Modification Factor K_1 for Flexural Members and Members in Tension Loading for Various Types of Loading.

Type of loading	Modification factor K_1
Dead load plus superimposed load	1.00
Dead load plus superimposed load plus snow load	1.25
Dead load plus superimposed load plus wind load	1.5
Dead load plus superimposed load plus snow load plus wind load	1.5



T.D.A. Standard Industrial Truss 59-ft. 2-in. span.

the minimum value quoted being appropriate to principals, binders or other components acting alone.

Wind and Snow Loading.

Reference has already been made to the fact that higher stresses can safely be employed for short duration loads. In computing the modification factors for wind and snow loading, it was necessary to make a careful study of meteorological data to determine a relationship between the intensities of wind and snow loads and the aggregate period throughout which they could be considered

Notched Beams.

Timber's apparent weakness in shear arises from its lack of tensile strength across the grain and consequently, in a beam, it will display horizontal shear failure very readily with certain kinds of notching, particularly with the kind illustrated in Fig. 1, the vulnerable sections being shown by dotted lines.

Research has shown that in a square cornered notch of this kind it is necessary not only to compute shear resistance on the basis of the reduced, effective cross-section (i.e. $b \times d_e$) but to reduce the permissible working stress in shear also, by multiplying

Structural Timber for Dock Work—continued

the basic stress by the factor K_3 where

$$K_3 = \frac{d_e}{d}$$

Obviously this form of notching is uneconomical and should be avoided if possible. Where circumstances have made this necessary, however, it has been found possible to maintain the shear strength by nailing and gluing side strips to the faces of the beam, as shown in Fig. 2.

The glue used should, of course, be durable and suited to the general conditions to which it is to be exposed.

Built-up Beams.

The development of moisture-resistant glues, and efficient gluing techniques has made it possible to reproduce in timber and plywood not only the efficient shapes associated with rolled steel joists and plate girders, but also the advantages of continuity which steelwork has derived from welding.

In building up a girder section it is, however, necessary to take into account a phenomenon which arises from the peculiar structure of wood. When a solid timber beam is subjected to flexure, the outermost fibres on the compression edge tend to behave like tiny Euler columns and are only restrained from buckling by the tensile forces which develop across the grain. In beams of I or box section (see Fig. 4) the elimination of timber near the neutral axis reduces the amount of lateral restraint which can be given to the highly-stressed outer fibres and consequently failure takes place at a lower compressive stress. This is taken into account by multiplying the basic stress by a modification factor K_4 (commonly called a form factor) given in Table 5, where the symbols b , d etc. have the meanings illustrated in Fig. 4.

Table 5.
Modification Factor K_4 for Flexural Stress in Members
of I or Box Sections.

Ratio	Ratio $\frac{d_2}{d}$								
	$\frac{b_1}{b}$								
	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
Modification factor K_4									
0.1	0.65	0.68	0.71	0.74	0.77	0.81	0.84	0.87	0.90
0.2	0.69	0.72	0.74	0.77	0.80	0.83	0.86	0.88	0.91
0.3	0.73	0.75	0.77	0.80	0.82	0.85	0.87	0.89	0.92
0.4	0.77	0.79	0.81	0.83	0.85	0.87	0.89	0.91	0.93
0.5	0.81	0.82	0.84	0.85	0.87	0.89	0.91	0.93	0.95
0.6	0.85	0.86	0.87	0.88	0.90	0.91	0.93	0.94	0.96
0.7	0.88	0.89	0.90	0.91	0.92	0.94	0.95	0.96	0.97
0.8	0.92	0.93	0.93	0.94	0.95	0.96	0.96	0.97	0.98
0.9	0.96	0.96	0.97	0.97	0.97	0.98	0.98	0.98	0.99
1.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

As will be seen from the Table, the modification factor K_4 does not exceed unity but, where the amount of material about the neutral axis is increased above the normal, as in the case of a circular section or a square section having a diagonal in the plane of bending, the flexural stresses may be increased, the form factor K_4 having in these cases the values of 1.18 and 1.414 respectively.

Slender Columns and Struts.

Tests on slender timber columns carried out at the Royal Aircraft Establishment and at the Forest Products Research Labora-

tory indicate a close agreement with the Perry formula:

$$p = \frac{p_y + (\eta + 1)p_e}{2} - \sqrt{\left\{ \frac{p_y + (\eta + 1)p_e}{2} \right\}^2 - p_e p_y}$$

where p = the intensity of end-stress which will cause the maximum fibre stress at some point in the length of the strut to reach the critical value p_y .

p_y = the critical stress. This is taken as the yield stress for all materials having a real yield point. In timber it may be taken as the ultimate compression stress.

p_e = the Euler stress.

η = an eccentricity coefficient. For free-ended timber struts it may be taken as equal to 0.002 l/r .

This formula was therefore adopted in calculating the values of the modification factor K_5 , by which the basic stresses in compression should be multiplied to obtain the permissible end-stress for any given slenderness ratio.

The strength of timber in compression parallel to the grain is greatly affected by the duration of the load, but there is no such effect on the modulus of elasticity. Therefore, since the strength of a compression member of low slenderness ratio is almost wholly dependent on the compression strength of the timber, its modification factor for duration of loading will be relatively higher than in the case of a very slender, Euler column, the strength of which is governed by the modulus of elasticity. The computed values of modification factor K_5 are given in Table 6.

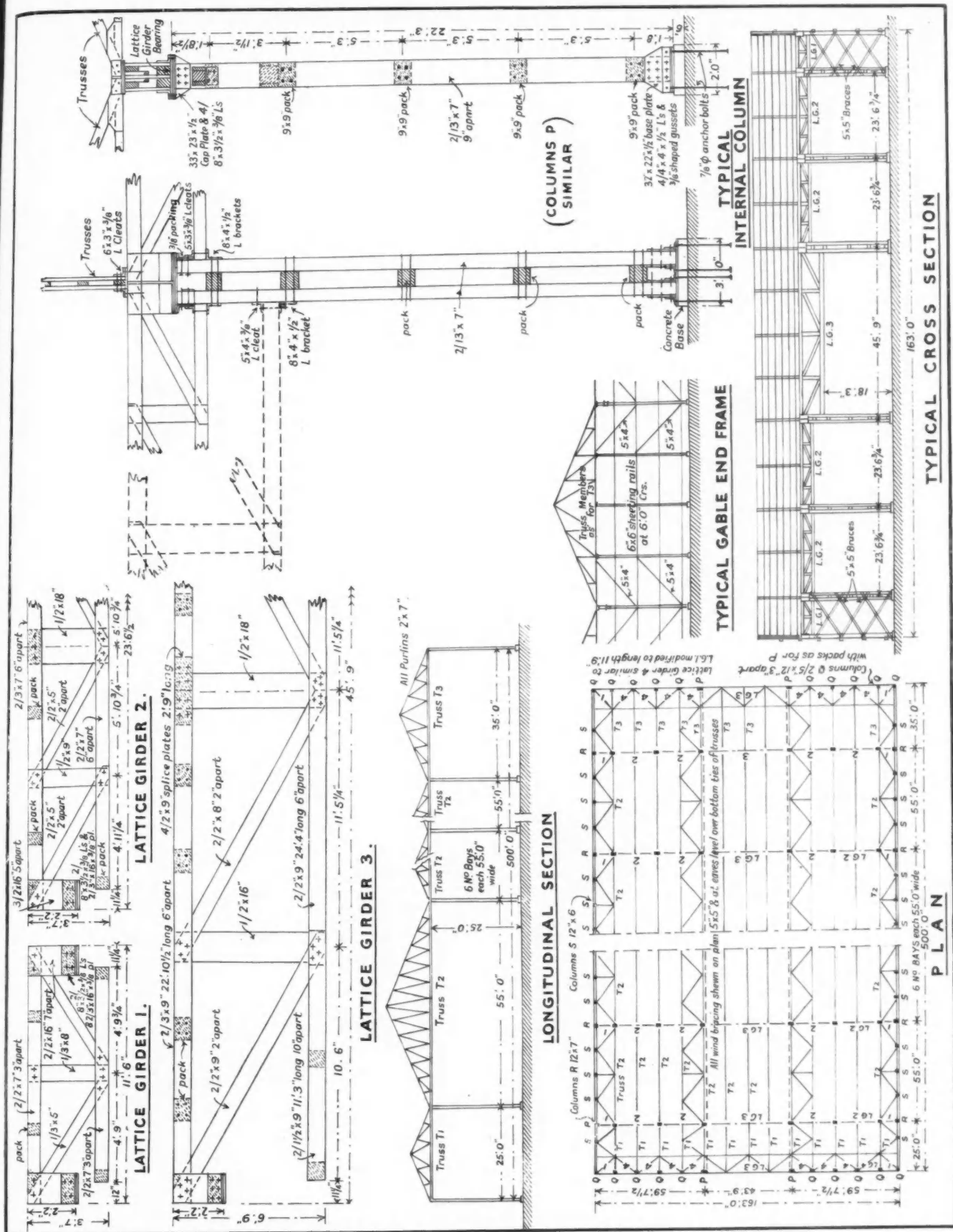
Table 6.
Modification Factor K_5 for Slenderness Ratio and
Various Types of Loading on Compression Members.

Values of K_5				
Slenderness ratio $\frac{l}{r}$	Dead load plus superimposed load	Dead load plus superimposed load plus snow load	Dead load plus superimposed load plus wind load	Dead load plus superimposed load plus wind load plus snow load
Less than				
5	1.00	1.25		1.50
5	.99	1.24		1.49
10	.98	1.23		1.47
20	.96	1.20		1.44
30	.94	1.18		1.40
40	.91	1.13		1.34
50	.87	1.08		1.27
60	.83	1.00		1.16
70	.77	.90		1.01
80	.70	.79		.86
90	.61	.68		.72
100	.53	.58		.60
120	.40	.42		.44
140	.31	.32		.33
160	.24	.25		.25
180	.20	.20		.20
200	.16	.16		.17
220	.13	.14		.14
240	.11	.12		.12
250	.10	.11		.11

Laminated Beams and Columns.

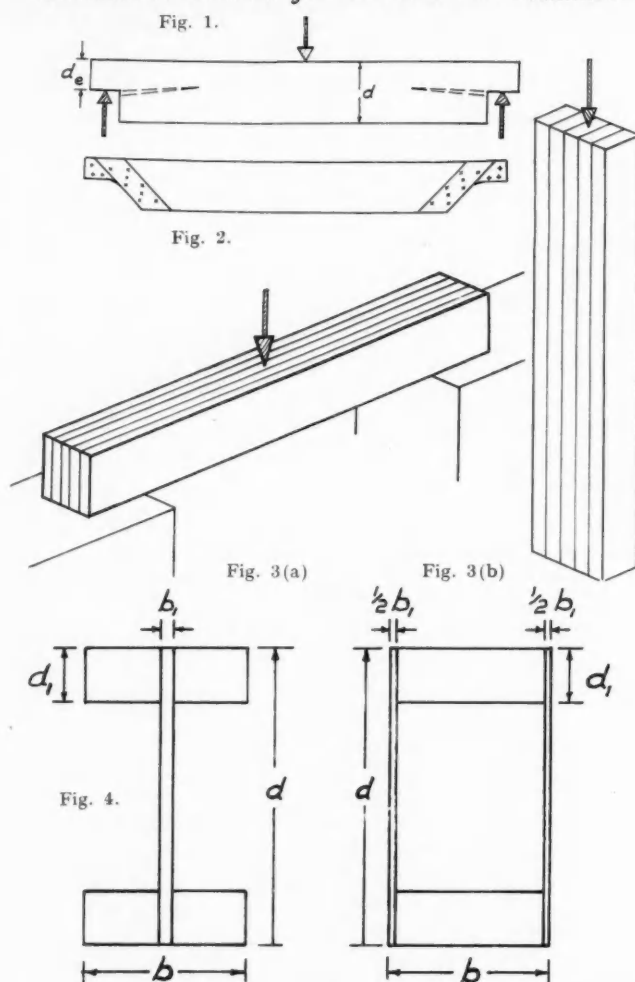
When safe working stresses are determined from the results of laboratory tests, reductions are made from the mean values to take into account the probability of occurrence of isolated minimum values. The greater the number of members or components which can be considered to be acting together, the closer will their aggregate strength approach the mean value of their test results. In certain kinds of construction it is therefore possible to reverse the mathematical process by which the minimum values for single specimens were established and thus compute increased permissible working stresses for multiple members.

The values in Table 7 have been calculated according to the number of laminations in a component subjected to flexure, compression and tension, and also for the effective increase in values of modulus of elasticity. The permissible stresses under these headings may be computed by multiplying the values of the basic stresses by the factors K_6 , K_7 or K_8 provided:



Design for Timber Storage Shed.

Structural Timber for Dock Work—continued



- (i) The laminations are of the full length of the member, of rectangular cross section, placed in contact face to face and fastened together throughout their length by nailing, bolting, gluing or other adequate means, so that they act together as one member.
- (ii) In beams, the laminations run at right angles to the neutral plane (see Fig. 3 (a)).
- (iii) In struts, the laminations run at right angles to the greater dimension of the dimension of the cross section (see Fig. 3 (b)).

Table 7.
Modification Factors for Laminated Members

No. of Members	Flexure K_6	Compression K_7	Tension and Modulus of Elasticity K_8
1	1.00	1.00	1.00
2	1.23	1.11	1.29
3	1.33	1.16	1.42
4	1.39	1.19	1.50
5	1.44	1.21	1.55
6	1.47	1.23	1.59
7	1.49	1.24	1.62
8	1.51	1.25	1.65
9	1.52	1.26	1.67

The Reconstruction of Greenwell's No. 1 Dry Dock and Ancillary Works at Sunderland

By HARRY RIDEHALGH, M.I.C.E.*

The paper deals principally with the construction of a new No. 1 dry dock at Sunderland, 675-ft. long, 87-ft. 6-in. wide at the entrance, and having 27-ft. 4-in. of water over the sill at M.H.W.S.

The site was previously occupied by a smaller dry dock, built in about 1880, which sustained damage at the entrance resulting in the gates and pumping facilities becoming inoperable. The new dock was in effect built round the old one.

The proximity of the entrance of the new dry dock to that of the main wet dock system of the port, through which uninterrupted access had to be maintained, made it necessary to construct the south roundhead inside a subsidiary cofferdam before the construction of the main cofferdam could be commenced. Experience gained during the construction of this subsidiary cofferdam, with particular reference to the badly fissured magnesian limestone beds encountered in the substrata, was of value during the construction of the main cofferdam which was of orthodox design embodying two rows of steel sheet piles between which pervious filling was placed.

Advantage was taken of the high rock levels in the body of the dock in preparing the design of the barrel walls, and it was possible to construct a relatively thin dock floor, the underside of which drained and vented through pressure relief valves placed at the bottom of the walls.

One additional 10-in. diameter centrifugal drainage pump was installed at the pump house of the neighbouring No. 2 dry dock, and by constructing a short tunnel between the new dock and this pump house it was possible to use the facilities therein installed to handle all water in both docks.

The largest "box" flap gate so far constructed is used to close the entrance to the new dock. The most interesting feature in this connection is the use of steel to steel meeting faces in which a rubber inset ensures the necessary water seal. In addition, the usual circular greenheart timber keel has been eliminated in favour of bearings at each end of the sill.

Coincidentally with the reconstruction of No. 1 dry dock and the provision of the usual crane and service facilities, No. 2 dry dock was extended by 50-ft. to a length of 565-ft., and the existing fitting-out quay was lengthened by 210-ft. to a total of 760-ft. Both these extensions were carried out without interfering with the owner's docking and repair programme.

The fitting-out quay extension was of reinforced concrete construction on vertical and raking piles, and the fendering system consisted of timber faced concrete blocks slung horizontally from the substructure.

Notes of the costs of the various portions of the work are included in the Paper, having been translated into "man-hours" as a guide when preparing future estimates.

Modernisation of Indian Ports.

The Government of India's scheme for the modernisation and development of India's major ports and the building of Kandla Port was outlined recently by the Transport Minister. According to "Indian Trade and Industry," the scheme is estimated to cost £30,000,000, of which £22,500,000 will be spent on expanding the five existing major ports. The balance will be spent on Kandla Port and the creation of port facilities for the oil refineries and alternative facilities for existing establishments on Butcher Island. Kandla Port will provide a natural outlet for the traffic previously handled by Karachi. It will serve the needs of the extensive hinterland of Punjab, Rajasthan, and Central India more economically than does Bombay, economy being achieved by the reduction of about 200 miles in transport. Improvements to Calcutta Port are expected to cost more than £8,250,000, to Bombay £7,500,000, and to Madras about £3,000,000. The plan for Cochin provides for construction of new berths for general cargo, whilst developments at Butcher Island include the construction of a pier.

*Summary of Paper read before the Maritime and Waterways Engineering Division of the Institution of Civil Engineers, on January 6th 1953.

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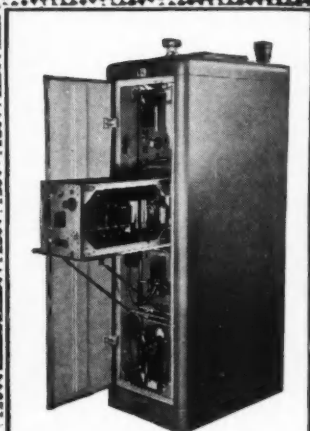
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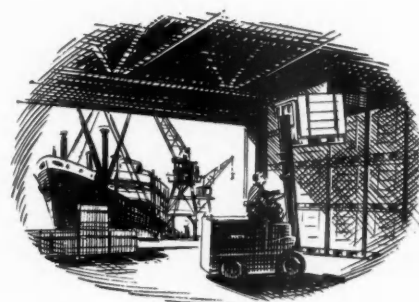
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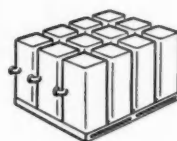
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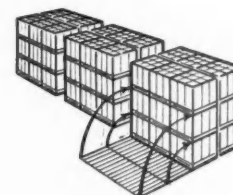
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Reinforced Concrete Ship Caissons

An Article for Students and Junior Engineers

By STANLEY C. BAILEY, Assoc.M.Inst.C.E.

General

SHIP or floating caissons constructed of reinforced concrete for closing the entrances of dry docks, or for dividing a long dry dock into two or more sections, have not so far been built, although they have the advantage over steel ones of not being liable to rust, and will not require periodical painting or tarring.

They are heavier than those formed of steel and consequently do not require so much either solid or liquid ballast to sink them in caisson grooves.

Ship caissons take longer time to operate than either gates or sliding caissons, usually about 15 or 20 minutes, as they must be moved clear of the entrance, and moored either in a recess in the walls of a long entrance or to wharf walls outside. A steel built ship caisson similar in external dimensions to the reinforced concrete one shown in the cross section Fig. 1, for an entrance 120-ft. wide at coping level and 50-ft. deep to the cill, and with side walls having a batter of 1 in 12 would weigh about 3 cwts per sq. ft. of entrance area (5,776 sq. ft.) or 866.4 tons, say 867 tons.

To sink this caisson in the entrance at H.W.S.T. 6-ft. below the coping, and a depth of water of 44-ft., the buoyancy being about 1,182 tons would require $1182 - 867 = 315$ tons of ballast, some of which would be solid, such as cast iron kentledge, or concrete in the bottom, and the remainder carried as water ballast in the tanks situated in the air chamber, there being water chambers above and below this.

A caisson constructed of reinforced concrete as shown in Fig. 1 will weigh about 1,575 tons, or 5.45 cwts. per sq. ft. of entrance area, its buoyancy without any ballast in 1,831 tons, therefore $1831 - 1575 = 256$ tons of solid and liquid ballast will be required, or 59 tons less than the steel caisson.

The increase of 649 tons in the buoyancy over that of the steel caisson is due to the thicker concrete skin, and the members in the upper and lower water chambers displacing more water than similar members in a steel one.

It is an advantage to reduce the amount of water ballast carried, as this means less pumping and a saving in time when the caisson is required to be removed. In some caissons a large part of the water ballast is placed in the trimming tanks under the top deck, these are emptied by opening sea valves, but the caisson is liable to rise with a jerk, it will be top heavy, and unstable until the water drains out.

It is not possible for the lower water chamber to be closed and filled with water by means of sluice valves for use as a tank, as this will involve the use of 2.4 times the quantity of 256 tons of water required to sink the caisson at H.W.S.T. and is more than the lower water chamber will hold, as the balance would still require to be put in tanks in the air chamber. The object of the shape shown in Fig. 1 is to lower the centre of gravity, to reduce rolling when floating, and to obtain sufficient buoyancy to float with 1-ft. freeboard to the top of the air chamber when solid ballast is added at the bottom. A narrower air chamber than 30-ft. will require to be over 16-ft. 6-in. high to give 1-ft. freeboard.

For example: Fig. 4, is a cross section of an older type of ship caisson, and Fig. 5, is that of a more modern form, they are both of equal cross sectional areas and weights, the areas being 960 sq. ft. and the weights at 32 lbs. per cub. ft. = 13.7 tons per lin. ft. for reinforced concrete caissons.

The caissons are not ballasted, and have no water chambers, the buoyancy of each will be $13.7 \text{ tons} \times 35 = 479.5$ cub. ft. per lin. ft.

In the case of the older type Fig. 4, the floating draught is 24.19 feet, the centre of buoyancy (C.B.) is 13.75 feet above the keel, and that the centre of gravity (C.G.) is 24.5 feet, so the pendulum distance between the C.B. and C.G. is 10.75 feet, and the ballast required to sink it with 1-ft. freeboard to the top of the central air chamber is 7.86 tons per lin. ft.

In the modern form Fig. 5, the floating draught is 20.98 feet, the C.B. is 12.75 feet above the keel, and the C.G. is 22.75 feet, the pendulum being 10-ft. while the ballast required to sink it giving 1-ft. freeboard to the top of the air chamber is 17.5 tons per lin. ft. as there are no water chambers.

As the distance between the C.B. and C.G. in both cases is considerable the caissons will not float vertically without bottom ballast. In some cases in addition to the cast iron or concrete ballast in the lower water chamber, similar ballast is placed on the floor of the air chamber; this is done to avoid the extra buoyancy or displacement caused by additional bottom ballast; but it is advisable when possible to deposit all solid ballast in the bottom to lower the C.G. and if any is put in the air chamber, it should be placed in tanks to prevent movement.

With regard to the buoyancy of an air chamber of rectangular cross section when entirely submerged, it is of course equal to the volume of water displaced, including the timber and concrete skin and any fendering, which when divided by 35 = tons; or the buoyancy equals the difference between the total upper and lower water pressures on the air chamber decks plus the buoyancy of the timber; or the difference between the upper and lower pressures per sq. ft. multiplied by the area in plan, plus the displacement of the timber; but in an air chamber of rhomboidal cross section in which the sides are splayed or converge, the buoyancy will be equal to the volume of water displaced, or will equal the difference between the upper and lower pressures in tons per sq. ft. multiplied by the mean area in plan; but will **not** be equal to the difference between the total pressures on the roof and floor of the air chamber.

Reinforced Concrete Ship Caisson

The proposed reinforced concrete ship caisson shown by Figs. 1, 2 and 3 for an entrance 120-ft. wide at coping, and 50-ft. deep to cill level, consists of an upper tidal water chamber (B), 15-ft. wide and 23-ft. 6-in. high; an air chamber (D) 30-ft. wide and 16-ft. 6-in. high, and a triangular lower water chamber (F) 30-ft. wide at the floor level of the air chamber and 10-ft. deep to cill level.

As there are no horizontal beams or stringers on the sides, the concrete skins have been thickened, being 6-in. and 7-in. thick in the upper tidal water chamber, 8-in. in the air chamber, and 9-in. in the lower water chamber; the vertical stanchions 1-ft. 6-in. x 9-in. are 8-ft. 4-in. apart longitudinally. The top deck (A) consists of 3-in. thick hard wood blocks laid in bitumen on concrete 7-in. to 9-in. thick; the two other decks, C and E, consist of 1-in. of asphalt laid on 7-in. of reinforced concrete. All the decks are supported by beams 1-ft. 6-in. x 9-in. thick, and may be considered as T shaped in cross section.

At the centre of the height of the upper tidal water chamber (B) there are cross beams with diagonal bracing in plan (Fig. 3) and also diagonal bracing in the elevation of the cross section (Fig. 1).

The air chamber (D) roof and floor are supported by central stanchions 9-in. x 9-in. at 8-ft. 4-in. centres longitudinally.

As the caisson can be reversed in the groove, elm timber fenders 9-in. x 9-in. on each side are shown, and for this reason the lower water chamber is filled through 12-in. diameter pipes with valves in the air chamber, the water passing up the 3-ft. diameter trunks to fill the upper tidal water chamber, with ventilation holes in the sides under the top deck.

The trimming tanks at each end of the caisson below the top deck will each hold 20 tons of water, but only a total of 24 tons will be required. They are filled by either fresh water from the mains (if any) on the entrance wharf, or by salt water supplied by portable pumps, and can be emptied by valves in the floor.

The scuttle tanks at each end of the caisson in the air chamber

Reinforced Concrete Ship Caissons—continued

(D) will each hold 92 tons, they are filled from the lower water chamber by valves in the floor, operated in the air chamber. There are also four rectangular steel scuttle tanks amidships in the air chamber, each 15-ft. x 6-ft. x 8-ft. high, each containing 20.5 tons, so the total ballast water capacity is 306 tons, but only 277 tons will be required, including 24 tons in the trimming tanks.

The steel tanks are filled from the lower water chamber by pipes with valves, and all the scuttle tanks can be emptied by the pumps in the air chamber, discharging either into the upper tidal water chamber, or preferably through a rising main to above the water level. The air chamber and all the tanks have ventilating pipes extending to the underside of the upper deck.

There are two ladders for divers between the top deck and the roof of the air chamber, these ladders are continued down to the bottom of the caisson through trunks 3-ft. diameter in the air chamber, there are also two steel trunks in the tidal water chamber with ladders for access from the top deck to the air chamber, and one trunk passing through the tidal water and air chambers, with a ladder to the lower water chamber.

Outside ladders from the top deck to the air chamber roof should be provided, also bollards and ring bolts on the top deck at each end of the caisson, and painted draught figures on both sides of the caisson near each end. Sluices with valves are not provided in the caisson for flooding the deck, as it is assumed that these will be placed in the walls of the dock entrance.

Weight of Caisson

The total weight of the caisson without any ballast is about 1,575 tons or 33 lbs. per cub. ft. of volume on exterior dimensions, and that of the reinforced concrete alone is 1,439 tons, or 30.09 lbs. per cub. ft., the total weight=5.45 cwt. per sq. ft. of entrance area. These weights are based on reinforced concrete weighing 149.3 lbs. per cub. ft. (15 cub. ft. per ton), asphalt 156 lbs., Trinidad bitumen 90 lbs., elm timber 40 lbs., Yarrah wood paving blocks 62 lbs. and Greenheart timber 70 lbs. per cub. ft.

Cast iron rectangular kentledge used as ballast weigh 448 lbs. per cub. ft. but when stacked its weight is about 400 lbs. per cub. ft. or 5.6 cub. ft. per ton.

Pig iron ballast=285 lbs. cub. ft. or 7.88 cub. ft. per ton; while ballast made of cement, sand, gravel, and steel burrs or punchings from plates may be so heavy as 350 lbs. per cub. ft. (6.4 cub. ft. per ton), but usually about 320 lbs. (7 cub. ft. per ton).

This can be made any suitable weight between 180 and 350 lbs. cub. ft. according to the proportion of steel burrs used.

Water Pressures on Caisson

The total lateral water pressure on the caisson when sunk in the entrance at H.W.E.T. 4-ft. below coping, the dock being empty, and due to a head of 47-ft. to the underside of the greenheart clapping timber of the keel is 31.55 tons x 117-ft.=3691.35 tons; and the pressure on the side walk at sill level for a depth of 46-ft.=1.314 tons per sq. ft. x 110-ft.=144.54 tons or 72.27 tons per sq. ft. on the timber and walls; as the ultimate crushing strength of greenheart is about 835 tons per sq. ft. there will be a factor of safety of 11.5. In the case of hard woods, the end and across the grain crushing strengths are almost equal. Demarara greenheart is the most suitable wood for bearing timbers, as it best resists the attacks of the *Teredo* mollusc, and of the crustaceans *Limnoria* and *Chelura*. The timber is not creosoted.

West Australian Karri wood, which has an ultimate crushing strength of about 740 tons per sq. ft. has been used for dock gates, but has been badly damaged by the above-named marine organisms.

The lateral water pressures on the caisson decks in tons, as shown in Fig. 6, are as follows, viz.: top deck (A) 31; horizontal braced girder (B) 360; deck C 967; deck E 1541; keel G 792, a total of 3,691 tons. Half of each of these pressures are of course transmitted by the decks to each wall, and at the keel, a portion will go to the walls, and the remainder=1.342 tons per sq. ft. x 106-ft.=142.25 tons on the keel with continuous bearing.

The vertical downward pressure on deck C due to 19-ft. 6-in. head is=0.557 tons sq. ft. x 2322 sq. ft.=1293.35 tons; and the

upward pressure on deck E due to 36-ft. head=1.028 tons x 2862 sq. ft.=2942.13 tons.

When there is H.W. on each side of the caisson at extraordinary tide (E.T.) level, the caisson being sunk in the groove, the downward pressure on deck C will be increased to 0.557 x 2432 sq. ft.=1354.62 tons, but the upward pressure on deck E will still remain=2942.13 tons.

Buoyancy of Caisson when Floating

When the caisson is launched after construction, with no ballast on board, its weight complete will be about 1,575 tons, there will be no water in the upper and lower chambers, as these are filled by pipes with valves in the sides of the air chamber. The floating out draught will be 22-ft. 9-in. to the underside of the keel, giving 4-ft. 9-in. freeboard from the water level to the top of the air chamber. Water is then admitted to the lower chamber F, the caisson will sink and the calculated amount of solid ballast required in the bottom can then be added to give 1-ft. freeboard to the roof of the air chamber; the buoyancy will be 1,578 tons and as the weight is 1,575 tons, only 3 tons of ballast will be necessary.

Concrete ballast formed of 1 part of cement, 2 parts of sand, and a suitable proportion of gravel and steel burrs, can be made of any required weight above 180 lbs. cub. ft. according to the proportion of steel burrs used; for instance if the ordinary concrete weighs 140 lbs. per cub. ft. and the required weight is 192 lbs. cub. ft. then 37 per cent. or 52 lbs. of steel burrs must be added.

Assuming that the ballast weighs 192 lbs. cub. ft., then 3 tons=6720 lbs. which divided by 192=35 cub. ft. will be occupied by it, this will displace 1 ton of sea water, so the buoyancy of the caisson will be increased to 1,579 tons, and its weight will be 1,578 tons, so there will still be an excess of buoyancy=1 ton, therefore 4 tons of ballast will be necessary to balance the buoyancy.

To avoid any further increase in the buoyancy, the weight of the ballast per cub. ft. can be augmented, so that it will not occupy more than 35 cub. ft.; and 4 tons=8960 lbs. which divided by 35=256 lbs. cub. ft. which is the weight of ballast required. Fig. 7 illustrates the caisson floating with 1-ft. freeboard to the top of the air chamber, and a draught of 26-ft. 6-in., the C.G. will be 6-ft. 6-in. above the C.B. the position of these points being obtained graphically by the diagrams shown in Fig. 8.

Buoyancy of Caisson when Sunk in Groove

The buoyancy of the caisson when sunk in the entrance groove at H.W.E.T. 4-ft. below coping with water on each side to that level, will be about 1,832 tons including 4 tons of solid ballast, and as the weight with that ballast is 1,579 tons, therefore 253 tons of water ballast will be required in the scuttling tanks, viz.: 82 tons in the steel tanks and 171 tons in the end ones, bringing the weight up to 1,832 tons. The caisson will then be in equilibrium and to ensure that it does not rise, if the water is rough, additional water may be added to the end tanks, or 24 tons put in the trimming tanks, making the total weight of the caisson and all ballast equal to 1,856 tons.

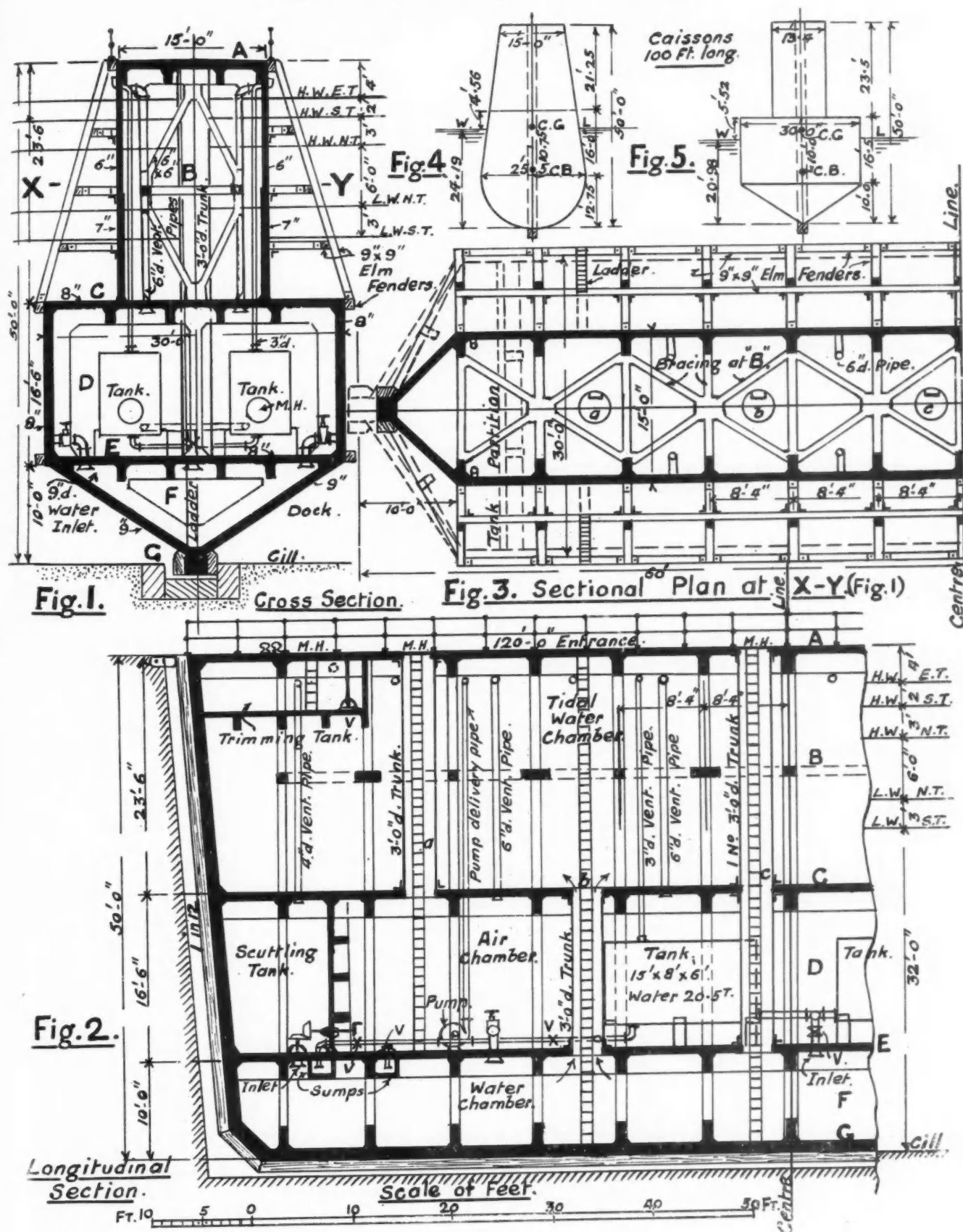
When the water is pumped out of the dock, the buoyancy will be partly reduced by deductions for the timber fendering, and the thickness of the concrete skin on the dock side, which will not be waterborne, the buoyancy of the air chamber will be increased from 1,525 tons to 1,760 tons, but the total buoyancy will be reduced by the downward pressure of the water on the sloping side in chamber F, next the dock. . . .

The buoyancy of the air chamber within the broken diagonal lines shown in Fig. 6 is 1,112 tons plus 3 tons for the outside fenders, a total of 1,115 tons, to which must be added 645 tons for the upward unbalanced pressure on deck E at x-y, making the chamber buoyancy=1,760 tons.

The total buoyancy is about 1,938 tons, which is reduced by the downward pressure of the water on the sloping side of chamber F, under a mean head of 41-ft. or 1.17 tons sq. ft. on an area of 1,378 sq. ft.=1612.26 tons, say 1612 tons, therefore the net buoyancy is 1938-1612=326 tons.

As the total weight of the caisson with all ballast on board is

Reinforced Concrete Ship Caissons—continued



Reinforced Concrete Ship Caissons—continued

1,856 tons, there will be an excess weight of $1,856 - 326 = 1,530$ tons, or 14.4 tons per lin. ft. on the caisson groove, neglecting the wall friction.

The least friction of the caisson against the walls at H.W.E.T. when the dock is empty will be the pressure or $3,691 \text{ tons} \times 0.38 = 1,402.58 \text{ tons}$, or 6.67 tons per sq. ft. of bearing area; but the coefficient of friction for wet timber on wet smooth stone may be so much as 0.6, it depends on the smoothness of the bearing surfaces; the granite is usually fine axed, and rubbed smooth with carborundum and need not be polished.

When the caisson is sunk in the entrance at H.W.S.T. 6-ft. below the coping, the buoyancy is about 1,811 tons, with high water on each side, and as the dead weight of the caisson is 1,579 tons including concrete ballast, the water ballast required will be 232 tons, in lieu of 253 tons at H.W.E.T. excluding the 24 tons in the trimming tanks, but no reduction should be made in this, because exceptional high tides may occur at any time during the spring tides, especially if a strong wind is blowing towards the caisson.

Fig. 9 shows the curve of buoyancy of the caisson with water on each side up to H.W.E.T. the weight on the caisson groove will be 24 tons due to the water in the trimming tanks; but at L.W.S.T. level, 32-ft. above the cill, the buoyancy is about 1,718 tons, and as the weight with all ballast is 1,856 tons, the pressure on the keel will be 138 tons or 1.3 tons per lin. ft.

To float the caisson out of the groove at H.W.S.T. a rise of at least 8-ft. between the cill level and the keel will be necessary, the buoyancy of the caisson will be 1,743 tons, and as the caisson with concrete ballast weigh 1,579 tons, therefore $1,743 - 1,579 = 164$ tons of water ballast is required, this will give a freeboard of 15-ft. and a rise of 9-ft. above coping level.

As the total water ballast in the tanks is $253 + 24 = 277$ tons therefore 113 tons of water must be removed to float the caisson, and if the 24 tons in the trimming tanks is drained away, only 89 tons of water need be pumped, or blown out of the tanks by compressed air.

Power capstans or winches and fairloads will be required on the entrance wharf walls to operate the caisson, and bollards and ring bolts to secure it in the caisson recess.

Calculations for Caisson

All the beams and the concrete skin may be calculated as being fixed at the ends with a B.M. $= \frac{W.L.}{24}$ at the centre, and $\frac{W.L.}{12}$ at the supports.

The top deck beams may be required to sustain heavy point loads from motor lorries or railway trucks.

The side stanchions in addition to the vertical loads from the decks, must also sustain the lateral water pressures on the skins; and should be treated as beams that are also under end compression. All the beams and stanchions should have double reinforcement, so that stirrups may be fixed.

When the caisson is completed and launched, with no water in the lower chamber (F), the lower deck (E) will be subject to top loads due to its weight, and that of deck C transmitted by the central stanchions in the air chamber, and the tension reinforcement will be at the bottoms of the decks and beams; but when sunk and water is admitted to chamber F the pressure will be reversed, and steel tension rods will also be necessary at the tops of the floor and beams.

With regard to the concrete skins, the tension steel of the skins of the upper and lower chambers should be near the outsides of the skins, but near the inside in the skin of the air chamber. Reversing the position of the caisson in the entrance will not make any difference to this placing of the reinforcements, whether the dock is full of water or not, for if there is water in the dock at the same level as that outside, the skins of the water chamber will have no lateral pressures, and those of the air chamber will have outside pressures only.

When the water is pumped out of the dock, the pressures will be on the outsides of the inner skins of the water chambers, and on the outside of the outer skin of the air chamber.

Should the water in the dock stand at a higher level than that

outside, which may occur if the tide falls several feet before pumping has begun, the pressures on the inner skins of the water chambers will be reversed.

The skin reinforcement should run horizontally from stanchion to stanchion, with $\frac{3}{8}$ -in. diameter vertical distribution rods at 12-in. pitch. The area of tension steel that will be required in the lowest portion of the 9-in. thick concrete skin of chamber F under a head of 46-ft. to H.W.E.T. per ft. depth on a clear span of 7-ft. 7-in. between the stanchions is as follows, viz.: the pressure is 1.314 tons per sq. ft. $\times 7\text{-ft. } 7\text{-in.} \times 1\text{-ft.} = 9.96$ say 10 tons; and the B.M. at the centre of the span $\frac{W.L.}{24} = \frac{10 \times 7.58}{24} = 3.15\text{-ft.}$

tons $= 84,672$ inch lbs. per 1-ft. width.

The effective depth (D) of the skin is 7-in. (allowing for 2-in. from the centre of the steel to the lower edge of the concrete.

The approximate area of the steel required will be $= \frac{M}{D.S.}$

$\frac{84,672}{7\text{-in.} \times 16,800} = 0.72$ sq. in. per ft. width, where S = safe stress per sq. in. on steel. Therefore 2 rods $\frac{3}{8}$ -in. diameter $= 0.88$ sq. in. per ft. at 6-in. pitch will suffice, with double this at the supports reversed in position.

To find the actual stresses in the concrete and steel, the proportional distance of the neutral axis from the compression side of the skin $= Z = \frac{C \times 15}{S + C \times 15} = \frac{650 \times 15}{16,800 + 650 \times 15} = 0.367$ and U the distance from the compression edge to the neutral axis $= 0.367 \times 7\text{-in.} = 2.57\text{-in.}$ where C and S = safe stresses per sq. in. on the concrete and steel respectively, and $\frac{E.S.}{E.C.} = \frac{30,000,000}{2,000,000} = 15$. By the graphic method of calculation $U = 0.428 \times 7\text{-in.} = 2.996$ say 3 inches. Taking $U = 3\text{-in.}$, and the area of the steel at 0.88 sq. in. and the area of the concrete in compression as a parabola $= \frac{2}{3} \times 3\text{-in.} \times 12\text{-in. wide} = 24$ sq. in., the centre of gravity of the parabola will be $U \times 0.4 = 1.2\text{-in.}$ from the compression edge and 1.8-in. from the neutral axis, the lever arm (a) from the C.G. of the parabola to the steel is 5.8-in.

The stress in the concrete $= \frac{M}{A_c \times a} = \frac{84,672}{24 \times 5.8} = 608$ lbs. per sq.

in. and in the steel $= \frac{M}{A_s \times a} = \frac{84,672}{0.88 \times 5.8} = 16,602$ lbs. per sq. in.

where A_c and A_s are the areas of the concrete and steel respectively. If the whole area of the concrete above the neutral axis is taken, with a triangular maximum compression area, the formulae are as follows, viz.:

Stress in concrete $= \frac{2 M}{A_c \times (D - \frac{1}{3}U)} = \frac{169,344}{36 (7 - \frac{1}{3} \times 3)} = 784$ lbs. sq.

in. Stress in steel $= \frac{M}{A_s \times (D - \frac{1}{3}U)} = \frac{84,672}{0.88 (7 - \frac{1}{3} \times 3)} = 16,036$ lbs. sq. in.

The concrete stress is rather high, and by the graphic method is much lower, but as the actual stress in the concrete depends so much on the aggregate mixture, its age, and ultimate compressive strength, it cannot be accurately determined unless these particulars are known.

For instance, taking the ultimate compressive strength of the concrete (1-2-4) when 7 days old at 3,460 lbs. sq. in. and when 150 days old, at 5,730 lbs. sq. in., from an actual test, and the ultimate tensile strength of steel rods at 58,000 lbs. to 105,000 lbs. per sq. in., the value of U may range between

$$U = \frac{3,460 \times 15}{105,000 + 3,460 \times 15} \quad D = 0.33 \times 7\text{-in.} = 2.31\text{-in.}$$

and $U = \frac{5,730 \times 15}{58,000 + 5,730 \times 15} \quad D = 0.59 \times 7\text{-in.} = 4.13\text{-in.}$ and the

value of $\frac{E.S.}{E.C.} = 15$ is also liable to variation.

With regard to the most suitable proportions for the concrete, a good strong mixture consists of 1 part of cement by measure, to 1½ parts of sand, and 3 parts of broken stone or gravel up to $\frac{3}{4}$ -in. size.

Reinforced Concrete Ship Caissons—continued

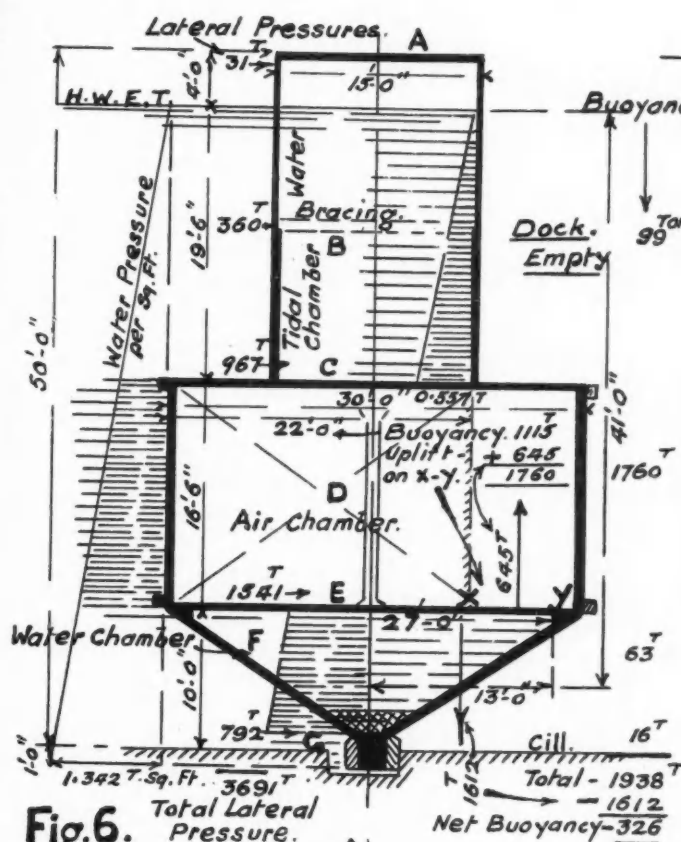


Fig. 6.

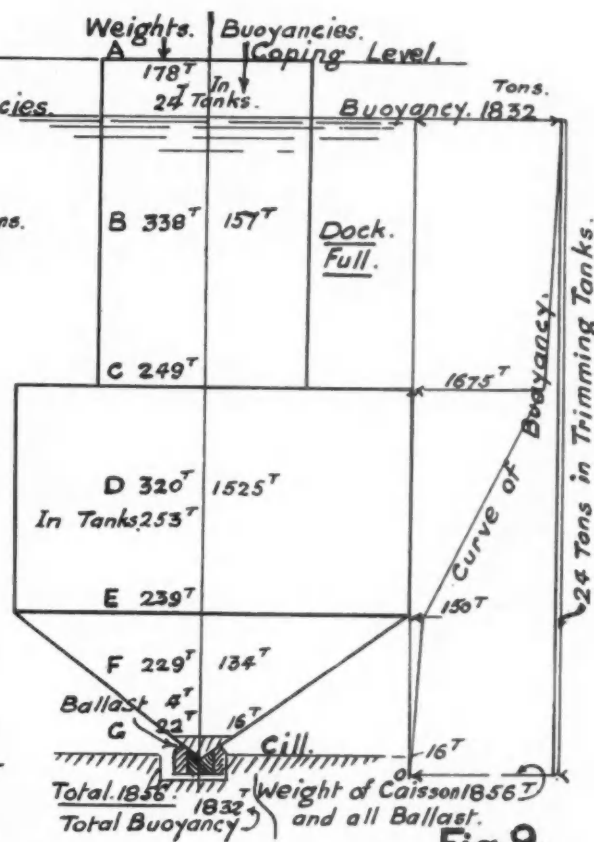


Fig. 9.

Fig. 7.

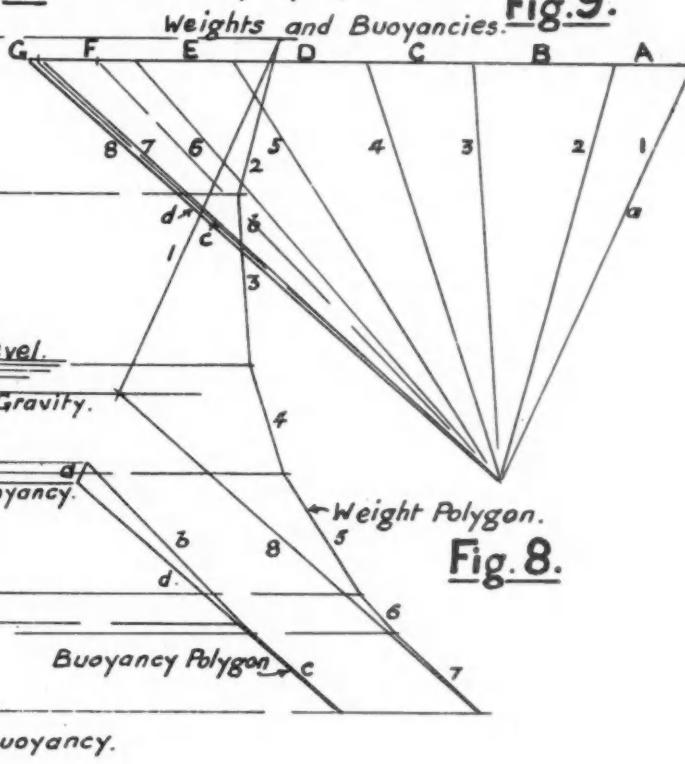
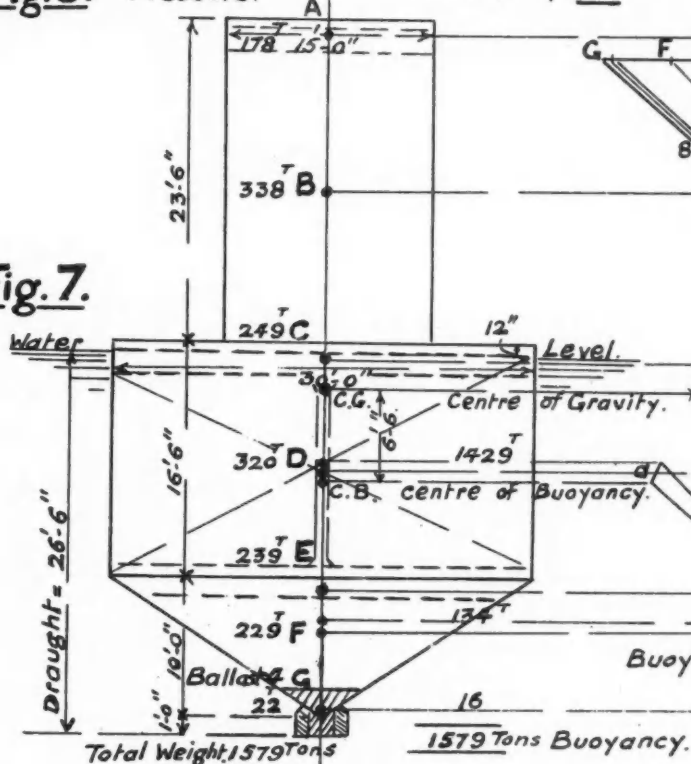


Fig. 8.

Corrosion and Preservation of Iron and Steel

A Review of Recent Technical Researches

By HENRY F. CORNICK, M.C., M.I.C.E.

THE subject of the durability of metal structures exposed to atmospheric and aqueous agencies is one of vital importance in docks and harbours, and until the inauguration in recent years of systematic research, the evidence was scanty, incomplete and inconclusive and so conflicting as to be actually perplexing. This state of things arose from a variety of causes. In the first place, it is only within the past century that iron began to usurp the pre-eminence hitherto enjoyed by wood and stone in maritime construction, and steel was an intrusion of still later date. Consequently there has only just elapsed sufficient time in which to acquire reliable data, for the determination of the actual life of metallic structures, more particularly steel, under various conditions and, moreover, experiments were not carried out from the earliest possible time. Again the variation in atmospheric conditions is extremely great, the seasons being marked by great fluctuations in sunshine, rainfall and temperature not only for different seasons in the same year, but for the same season in consecutive years. The question is still further complicated by the factor of locality. Then, as regards aqueous influences, there is no definite standard of comparison. The salinity, acidity, density, and temperature differ in almost every unit volume of sea-water, so that it is never precisely the same at any two ports. Rivers, sewers, and ocean currents all contribute to differentiate its composition. In addition, the various qualities of iron and steel offer varying resistance to different types of corroding agents.

Early Theories and Work.

As early as 1819 an anonymous writer — understood to be Thénard — expressed the opinion that rusting was an electro-chemical phenomenon, whilst Davy proposed the use of iron or zinc to afford electro-chemical protection for copper against corrosion by sea-water. Another electro-chemical interpretation of corrosion was put forward in 1838 by Mallet, whilst Faraday's writings are full of emphasis on the essential connection between voltaic current and chemical action. Since then there have been five main theories put forward—the Acid, Hydrogen Peroxide, the Older Electro-chemical, the Colloidal and the Newer Electro-chemical theories.

In view of the inadequacy of the earlier theories, numerous series of exhaustive technical investigations on various parts of the subject have been carried out during the past 30 years or so, by organisations representing metal manufacturers and users, private firms and institutions having a semi-official and official character.

Among the many research workers in the various fields of investigation may be mentioned Aston, Evans, Friend, Bengough, Cushman and Gardiner, Hudson, Hadfield, Hatfield and Vernon.

Their researches and those of Sir Robert Hadfield commencing in 1920, did much to repair the deficiencies in the earlier evidence on the subject, his first treatise¹ on the matter was produced in 1921 and his last in 1936². In the U.S.A. the National Bureau of Standards commenced in 1922 a long term field investigation of the problem, and about this time the Institution of Civil Engineers convened a technical committee to carry out experiments and research, which from time to time published interim reports. The latest is the fifteenth and is dated 1935, and these reports deal at length with the deterioration of materials exposed to the action of sea-water. Much important research has been also carried out by the D.S.I.R. Chemical Research Laboratory³.

Nature of Corrosion.

By corrosion is meant the wastage of metals which it is now known is caused not only chemically but by electro-chemical agencies, in the many diverse environments in which metals are used. The problem in modern times is assuming special signifi-

cance, apart from the monetary losses involved. It is at last being realised that supplies of basic materials are by no means inexhaustible, and therefore must be conserved, thoughtless exploitation and profligacy in their use being avoided. The preservation of materials is thus extremely desirable, and in the case of steel, looking into the distant future, may even become a pressing economic necessity, unless preservation methods are greatly improved or alternatively some forms of non-corrosive alloy steel can be manufactured universally in sufficient quantity at economic prices.

The subject of corrosion and preservation of metals is a wide one, which is not, in its entirety, within the scope of a treatise such as this. It is hoped, however, that what follows will prove of interest and value to readers as a basis for possible further study of the research which has been carried out, a bibliography of which will be found at the end of the chapter.

The nature of corrosion of metals may be stated as their constant effort to revert to the stable condition of the mineral. The reduction of a metal from its natural state of combination with other elements is achieved by the expenditure of energy and it follows that only in the so-called "noble" metals, headed by gold, is the metallic state naturally stable. The tendency of a metal to corrode may be expressed numerically by the amount of energy liberated in the change from the metallic to the oxidised state; or in electro-chemical terms, by the standard electrode potential of the metal.

The so-called Hydrogen Scale of Potential is that in which the potential between blackened platinum saturated with hydrogen under one atmosphere pressure and an acid solution of normal hydron concentration is taken as zero, just as the temperature of freezing water is taken as zero on the Centigrade thermometer.

By arranging the metals in the order of their normal electrode potentials, we get what is known as the Electro-Chemical Series⁴. Table I shows this series in abbreviated form.

Table I
The Electro-Chemical Series

Metal	Ion Considered	Normal Electrode Potential ^a Volts
'Noble end'		
Gold	Au ⁺⁺⁺	+ 1.42
Silver	Ag ⁺	+ 0.80
Copper	Cu ⁺⁺	+ 0.345
(Hydrogen)	H ⁺	0.000
Lead	Pb ⁺⁺	— 0.125
Tin	Sn ⁺⁺	— 0.135
Iron	Fe ⁺⁺	— 0.44
Zinc	Zn ⁺⁺	— 0.76
Aluminium	Al ⁺⁺⁺	— 1.67
Magnesium	Mg ⁺⁺	— 2.34
Lithium	Li ⁺	— 3.02
'Base end'		

Notes: ^aPotential in salt solution of normal ionic activity relative to the Normal Hydrogen Scale of Potential as arbitrary zero, at 25°C. The closer two metals are together in this series the less will be the danger from electrolytic corrosion.

This table does not give either the rate or the mode of corrosion in a given environment, otherwise the corrosion problem would be simpler than it is. It is necessary to consider other factors superimposed upon the initial corrosion tendency as represented by the values in the table. For example, the extreme reactivity of aluminium under normal conditions leads to the formation of a film of oxide (alumina) which effectively suppresses continued attack upon the metal beneath it. The same action occurs to some extent with all metals.

Corrosion and Preservation of Iron and Steel—continued

Analysing the corrosion of immersed metals, the liberation of energy which occurs when corrosion takes place is accompanied by a redistribution of electrons which, if conditions are favourable, may produce recognisable electric currents. These can be visualised by considering a simple voltaic cell (see Fig. 1), all the features of which have their counterpart in ordinary immersed corrosion, even though separate anodes and cathodes cannot

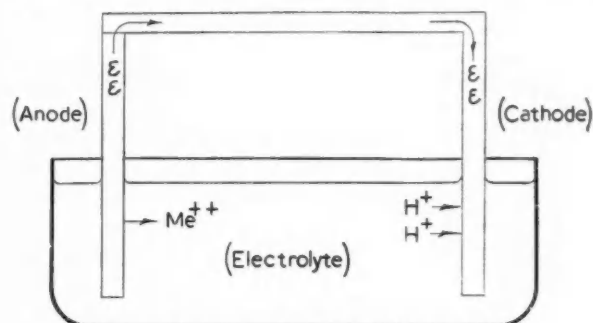


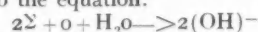
Fig. 1. A simple Voltaic Cell.

always be visually distinguished. The corrosion process may be regarded, in view of the evidence, to be made up of anodic and cathodic components which can be influenced respectively by appropriate means.

The voltaic cell (the electrolyte being a dilute acid solution) represents the "Hydrogen Evolution Type" of corrosion, in which corrosion is a function of the amount of hydrogen evolved. Here the cathodic reactions may be represented as follows:



Hydrogen evolution corrosion is normally associated with acid industrial waters. In neutral salt solutions, however, the accumulation of electrons in the cathode is presented (except in very reactive metals) only by the intervention of oxygen, which becomes reduced according to the equation:



This constitutes the "Oxygen Absorption Type" of corrosion. In the more general case in which alkaline salts are present, the formation of Hydroxyl ions at the cathode must accord with the formation of free alkali.

U. R. Evans describes experiments by which it may be shown quite clearly that the mechanism of corrosion of metals is electrochemical in character, and that the four main parts of the process can be demonstrated, these are:

- (1) The production of an electrical current;
- (2) The production of a soluble metallic salt (chloride) at the anodic (un-aerated) places;
- (3) The production of alkali (Hydroxide) at the cathodic (aerated) places; and
- (4) The precipitation of an insoluble hydroxide where the products from the cathodic and anodic areas meet.

For example, with iron immersed in a solution of sodium chloride, the primary anodic product is a soluble iron chloride and the cathodic product sodium hydroxide. By precipitation we get white ferrous hydroxide, but in the presence of oxygen it rapidly oxidises and becomes green in the lower surface (ferroso-ferric hydroxide) and brown on the upper surface (ferric hydroxide), this mixture of iron hydroxides being what we know as "rust."

The agents by which the course of corrosion may be influenced are of many kinds and may be conveniently classified as "promoting and controlling" factors, or those associated with the metal and those connected with the environment. The former include, for example, electrode potential, surface condition, including internal stresses. The actual amount of corrosion almost invariably fails to reach the value of the calculated amount and it can be recognised, therefore, that there are controlling factors which have some influence in restricting the corrosion attack on the metal. In immersed corrosion they may be either the complex phenomenon associated with "hydrogen over potential" in "Hydrogen Evolu-

tion Types" of corrosion, or in the "Oxygen Absorption types"; the rate at which dissolved oxygen can reach the metal surface, actually the cathodes of the corrosion system. The sensitivity of the cathodes to oxygen supply is seen in the influence of depth of immersion under normal atmospheric conditions.

It is clear in stagnant water conditions, assuming acid activating agents to be absent, that the replenishment of oxygen to the surface of the metal will be more readily effected the less the depth of water between the metal and the air, until the layer of water becoming progressively thinner the condition of the air formed film of oxide is reached, which always forms upon a metal surface exposed to air. In the case of atmospheric exposure, humidity provides the electrolyte, and in industrial atmospheres this is invariably acid in character.

Experiments by J. Newton Friend⁶ established the link between immersed corrosion and atmospheric oxidation. By progressively increasing the speed of movement of aerated water over steel he showed that the rate of corrosion likewise increased, but that where a critical speed of movement was reached the increase in corrosion gave place to falling values. Increasing the speed still further it was found that complete inhibition of corrosion occurred, the specimens remaining quite bright and rustless.

Two interesting cases, with which the writer is personally acquainted, and which seem to provide instances, in practice, of immunity from corrosion in rapidly moving waters are as follows. In renewing two floating caissons at Tilbury Dry Dock in 1922, it was necessary to remove the greenheart sill timbers upon which the old caissons rested. When the 14-in. diameter wrought iron bolts and nuts which secured the timbers to the granite sill had been cut off and brought to the surface by a diver, they were found to be quite bright. No doubt the greenheart had preserved the shank portions of the bolts embedded therein, but the nuts and portions of threaded ends in contact with rapidly moving water, due to leakage for many years, may have been the means of their preservation since 1883. The other case is that of the wrought iron semi-circular bottom plates of the pontoons of Westminster Pier. Upon the occasion of one of the ten-yearly dry docking operations in 1927, the surfaces of the portions of the plates which had been in contact with the rapidly moving ebb and flood tides of the Thames were found to be in a bright and almost polished condition, there being no evidence of surface corrosion except for a few pitted depressions which were also bright. These pontoons

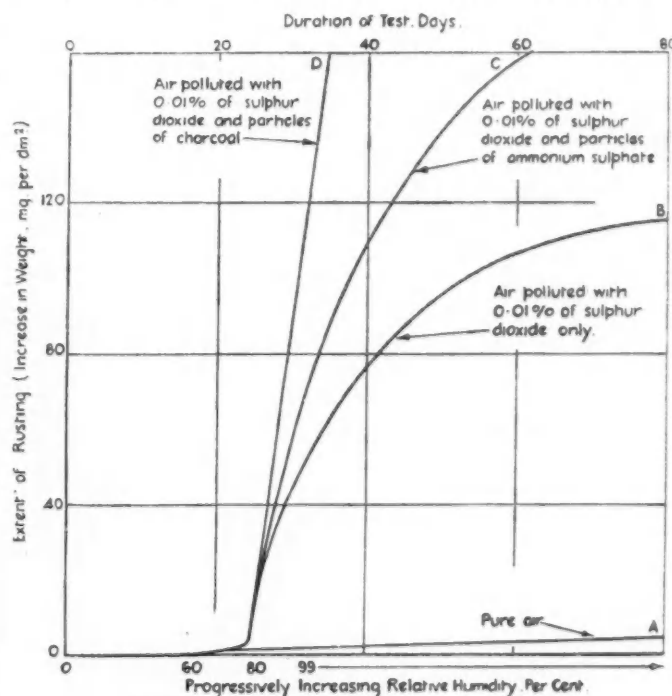


Fig. 2. Atmospheric Humidity and Corrosion.

Corrosion and Preservation of Iron and Steel—continued

originally formed parts of the semi-circular dams with which Bazalgette constructed the Victoria embankment in the middle of the 19th century.

Dr. Vernon, before mentioned, showed by experiment⁷, the effects of progressively increasing relative humidity on the corrosion of iron specimens with and without the presence of atmospheric pollution and his curves in Fig. 2 give the results. He points out that: (a) at relative humidities less than 60 per cent. there is no visible change whether the air is polluted or not, and

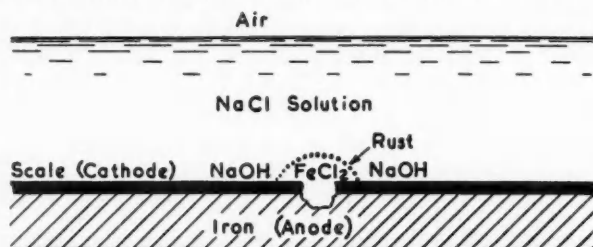


Fig. 3. Localised Corrosion.

that up to this amount of humidity, film formation is predominant, (b) within the range of 60-80 per cent. some rusting occurs and the film is evidently breaking down, and (c) when this critical humidity range is exceeded there is a relatively enormous increase in the rate of corrosion, provided only that traces of pollution are present. Curve C shows the added effect of the typical constituent, ammonium sulphate, of ordinary solid atmospheric pollution. While the most remarkable example of gaseous and solid pollution acting together is provided by particles of charcoal, and it is clear that the action of them must be primarily physical, locally increasing the concentration of sulphur dioxide by absorption. There would seem to be little doubt that a similar function may be played by carbonaceous particles in ordinary atmospheres in which, as in the experiments, gaseous pollution is represented by the presence of sulphur dioxide.

It follows from consideration of these curves that at high relative humidities, which are the normal service conditions in this country over long periods, the controlling factor is provided entirely by the purity of the atmosphere. Work in this field of observation is being pursued at the Chemical Research Laboratory.

Distribution of Corrosion.

With regard to distribution of corrosion, the simplest and least dangerous case is that of corrosion distributed uniformly over the whole surface of the metal. Localised corrosion, however, when it takes the form of "pitting," may lead to more or less rapid perforation. Fig. 3 (Dr. Vernon) indicates what occurs in such cases in neutral solutions or natural waters, i.e. a film or scale forms, which is capable of acting as a cathode, when the underlying metal becomes exposed at any point. The important feature of the formation of rust is that its presence may offset further corrosion and in two different ways. A layer of dried rust may tend to protect the metal just below it and aid attack upon areas immediately surrounding it, by functioning possibly as the cathodic member of the electro-chemical system. On the other hand, a wet patch of rust is usually favourable to the continued corrosion of the metal beneath it, mainly due to the shielding of it from oxygen, so rendering it anodic. While the cathodic area is thus protected, the danger of the situation arises from the fact that oxygen reaching the relatively large area of the metal surface functioning cathodically may directly contribute to the corrosion of the small anodic areas. The actual distribution of anodic and cathodic areas is determined by the part which the distribution of dissolved oxygen may play, and is the basis of the "Differential Aeration Principle" associated with the work of Dr. U. R. Evans⁸. This is somewhat complex and there are certain tendencies which however paradoxical can be explained scientifically.

Apart from the development of cathodic and anodic areas due to the effects of differential aeration, variations in salinity also play their part, consequently, in maritime structures of steel, certain

parts may be heavily attacked while others may be only slightly affected. Again experiments carried out by the Institution of Civil Engineers Committee on the Deterioration of Structures Exposed to the Action of Sea-water show that various qualities of iron and steel offer widely varying resistance towards different types of corroding agents. For example, one type may suffer severe corrosion when exposed to sea-air, whilst another may suffer maximum corrosion when continuously immersed in sea-water.

Underground Corrosion.

Underground corrosion is a problem of equal importance to countries as a whole, when one considers the thousands of miles of buried cast iron and steel water, gas and hydraulic mains owned by public utility concerns, and the dock engineer is also greatly concerned in regard to such service mains on dock properties.

Corrosion of cast iron takes the form of "graphitisation" and may occur when the metal in, for example, the form of pipes, is buried in impervious clays, and even at great depths in the sea. There is evidence, however, that in fresh water this form of corrosion does not occur. There is ample evidence of the deterioration of cast iron by "graphitisation" in alluvial deposits and clays and the following cases may be cited of immersion corrosion in water: "Cast iron cannons from a vessel which had been sunk in the fresh water of the Delaware River for more than 40 years, were perfectly free from any corrosion. On the other hand, the cast iron work of the 'Royal George' and the 'Edgar' sunk in the sea for 62 years and 133 years respectively, when examined, had become quite soft and resembled plumbago. The wrought iron was not so much injured except where in contact with copper, brass or gun-metal."

Cast iron hydraulic and gas service mains buried from 3-ft. to 5-ft. in clays and waterlogged made up ground at Tilbury Docks, Essex, when removed for repair and renewal after periods of from 10 to 30 years were found to be completely graphited but still perfect in shape. The author had some stretches of pipes relaid in chalk but the protection results, if any, are not yet known.

Judged from the electro-chemical corrosion viewpoint these results are apparently incompatible. It would be expected that the specimens of cast iron in sea-water in any case would likewise have suffered little or no deterioration, under conditions in which the rate of oxygen supply must have been excessively small and considering the virtual absence of corrosion which is normally associated with such conditions, exemplified by the condition of the wrought iron in sea-water and the cast iron in fresh water and ground. The inference, therefore, is that extensive graphitisation of cast iron in sea-water and ground is directly associated with conditions which, in view of the electro-chemical principles set out, should lead to immunity from corrosion. That is to say it is favoured by the exclusion of oxygen.

Antithetical results such as these remained unsolved for many years, indeed their significance was not suspected until a Dutch scientist, Wolzogen Kuhr, in 1934 suggested, as an explanation, the possible action of anaerobic sulphate-reducing bacteria which, in his view, acted as "hydrogen acceptors" and provided a medium for the disposal of cathodic hydrogen, a role normally filled by atmospheric oxygen. Research in this field of observation was taken up by the Chemical Laboratory of the D.S.I.R. and Kuhr's views were confirmed in principle, and experiments have shown, in neutral solutions from which oxygen is excluded, that corrosion occurred only in the presence of the bacteria. Uncertainty, however, still exists as to whether sulphate simply takes the place of oxygen in ordinary anaerobic corrosion under neutral conditions. Anaerobic bacteria (*vibrio desulphuricans*) of the sulphate-reducing types are known to exist in certain areas of the sea-bottom and what is of much greater significance and importance is that they also flourish in many impervious clays and it is true that the majority of clay soils contain all the conditions for microbiological corrosion, i.e., exclusion of oxygen, presence of sulphate, of bacteria and of factors favourable for their growth.

Laboratory experiments have been confirmed by observations in the field, for example, the obvious presence, around buried cast iron systems, of hydrogen sulphide when they are first exposed, the local blackening of the soil due to presence of ferrous sulphide,

Corrosion and Preservation of Iron and Steel—continued

and the greatly increased concentration of bacteria in the immediate vicinity of the corroding metal, provide the invariable symptoms of microbiological corrosion.

Much valuable information on the subject of underground corrosion of both ferrous and non-ferrous metals and alloys has resulted from field experiments and observations conducted by the National Bureau of Standards of the United States of America¹⁰. Studies of buried metal pipes of various materials over periods of two and 14 years formed the basis of the research. Certain steels containing high percentages of chromium and nickel were found resistant and no appreciable weight loss or pitting being detected even after the maximum period of exposure. It was pointed out by the Bureau that immunity to corrosion shown by small test pieces does not necessarily mean that a large structure of the same material will last indefinitely. The effect of expanding the area may have a direct effect upon pitting. It was also noted by the Bureau that the small amounts of nickel, chromium and molybdenum, which produce high resistance to atmospheric corrosion in the modern high-strength steels, contribute little to their corrosion resistance underground. The microbiological corrosion of iron and steel did not form the subject of investigation.

Unresolved Problems.

There are many phenomena and reactions which occur in some forms of corrosion which are not yet fully understood or have not yet been resolved and a considerable amount of research work has still to be done in many directions.

The effect of stresses and strains in corrosion have been investigated and it seems likely that stress does effect a change in potential which may cause corrosion to be distributed in a way connected with the stresses in a metal. Other changes in corrosion brought about by mechanical deformation of the metal during rolling or working may, however, be equally important. Such effects are particularly noticeable in practice, at welded joints and laminations in wrought iron and steel.

It is also well known that rapid atmospheric corrosion takes place more particularly at joints and crannies and corners where portions

of steelwork come together forming pockets which get filled up with water and dust. Another example of places where excessive corrosion is likely to occur is at the heads and points of rivets, and heads and nuts of bolts—all heavily worked, subject to deformation and stress.

At one time it was thought that an absolutely pure metal—if it could be obtained—would be very resistant to corrosion. This, however, is not true in every case, but it is a fact that some impurities increase corrosion effects and others decrease that liability. Among the latter are nickel, chromium and cobalt, while manganese considerably increases the attack, but in the presence of sulphur manganese is not an objectionable element in steel.

The majority of the so-called non-corroding alloys contain one of the following elements, nickel, chromium, cobalt, aluminium or silicon, others contain copper, molybdenum, tungsten or lead. It seems that the production of resistant metal alloys for structural work, ferrous and non-ferrous for other purposes, provides a field of research to which an increasing amount of attention will be devoted in the future.

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(To be continued)

The Choice of a Grab Their Application and Operation

Grabs for handling bulk material have been evolved over a considerable period of time, and available records suggest that the primary reason for the inception was a recurring need for the removal of material from underneath water.

In Europe the silting up of canals such as those in Venice presented a serious problem. Hence it is not surprising that the earliest extant design for a grab is to be found in one of the sketchbooks of Leonardo da Vinci (see Fig. 1).

It was not until 1848 that an American named Morris patented what he called "a mud scoop," which was provided with a compound, or differential, drum so as to give the jaws increasing power as they closed. Two chains were used for operation, one to hold the grab while discharging and the other to close and hoist; thus it will be seen that, in this instance, a crane equipped with double drums, was needed. From this stage the usefulness of two jaws which could dig into material and hold it, was realised. From that time the number of different types and sizes has been ever increasing until to-day the prospective user can obtain a grab entirely suited to his particular requirements.

It is not to be expected that the user will always be able to make his own choice—that is, the best choice. This is the job of the specialist, but in an effort to help engineers, stevedores, dock and harbour authorities and bulk material handling companies of all types, Messrs. Priestman Brothers Limited have issued a booklet entitled "On the Choice of a Grab," the aim of which, as its title implies, is to help buyers to select the best grab for the particular job in mind.

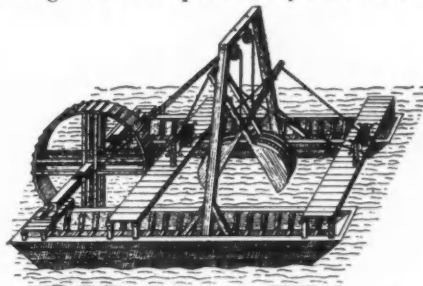


Fig. 1.

"Why are so many types of grabs made?" is a question which is often asked. The answer is that such a wide range is necessary because of the increasing variety

of working conditions to which grabs are now applied, and because the aim is to ensure the most efficient handling of any material in conjunction with these conditions.

There is an ever-growing demand for information about the application and operation of grabs and this booklet tells some of the differences that exist in the construction, suspension and design of grabs.

The "choosing" has been simplified by dividing the booklet into three main parts and analysing each in turn:—

- (1) The material to be handled.
- (2) The lifting equipment available.
- (3) The working conditions.

The Material to be Handled.

To take an extreme case, very heavy digging should only be undertaken by a "Whole Tine" grab as illustrated in Fig. 2. This would not be suitable for the handling of fine material such as loose phosphate where a plate grab is required with a special shape of jaw and an efficient seal between the lip edges (see Fig. 3). Thus it will be seen that the type of material governs the type of jaw.

The booklet tabulates a selection of materials, sometimes separating these into sizes, varieties, weights and densities. Recommendations for the type of jaw to be used are also given. This tabulation should be used in conjunction with the technical sheets, also issued by the Company. These

give detailed information of capacities, weights and leading overall dimensions of grabs.

Photographs in the booklet illustrate a few of the standard types and special types of jaws used for handling different materials.

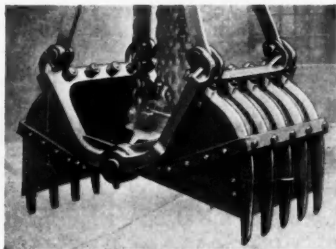


Fig. 2.

Lifting Equipment Available.

There is an infinite variety of lifting or hoisting equipment from which grabs can be operated, including small mobile cranes, single and double drum jib cranes, ships' derricks, overhead cranes, telfers, runways, transporters and large dockside cranes.

No single mechanism for closing the grab in the material, hoisting the loaded grab, and then discharging the material where it is required, can possibly suit such a diversity of suspension arrangements. It is this fact, coupled with the limitations imposed by the materials and the conditions on site, which makes necessary so many combinations of grab operating mechanism and individual types of jaws.

In the booklet a selection of these lifting and hoisting equipments has been summarised showing the method of operation which has to be incorporated in the grab.

Double-line and multi-line grabs are the simplest types available, the mechanism of which consists only of sheaves around which the rope or chain is reeved to give the necessary digging purchase. On this type of grab the holding rope(s) are attached to the grab head, whereas the closing rope(s) are reeved around the grab sheaves and anchored within the grab. The crane operator can partly or fully discharge the contents of the grab at any height. Double drum cranes are required here.

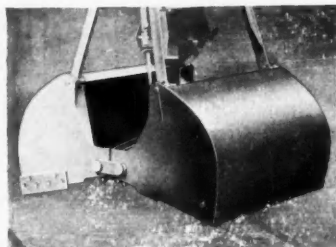


Fig. 3.

On single drum cranes, mechanism has to be incorporated in the grab, so that it can be held in the open position during lowering to dig. This complicates the mechanism slightly and necessitates the use of various combinations of buttons, tumblers, pawls and springs.

The Choice of a Grab—continued

Grabs have also been designed which are suitable for small mobile jib cranes where the headroom under the crane hook is limited and quick conversion to lifting duties is required. Attachment is made by means of a yoke plate which is merely slipped over the crane hook.

Working Conditions.

The conditions under which the grabs are required to work can alone govern the design. Limitations in the headroom and operating area available often call for specialised types of grabs.

An example of this can be a grab designed solely for ship-discharging. It is in this particular field of operation that grabs are likely to receive their severest test, as in addition to their having to combine features which will suit varying and sometimes conflicting factors, they also have to be of sufficiently robust construction to stand up to the severe handling associated with this work.

Limited headroom under the ships' coamings or 'tween decks and the necessity for reaching under these obstructions to reduce hand trimming, calls for a grab combining minimum height with maximum jaw opening (see Fig. 4).

Other specialised applications call for the use of circular grabs (Fig. 5) which have been specially manufactured to undertake



Fig. 4.

work in connection with cylinder sinking, excavating and maintenance of wells and any other instances where the circular dimensions limits the size of a grab.

It will be seen therefore that manufacturers of grabs must be supplied with full details of the working conditions before they can suggest the most suitable design. When considering bulk handling problems it is suggested that the following points be remembered, and communicated to the manufacturers:

- (1) The kind of material to be handled, giving details of weight or density and some indication of its size and condition.
- (2) The type of equipment from which the grab is to be operated giving the safe working grabbing load.
- (3) Some details of the working cycle which is required, such as whether the

material is to be excavated, dredged, lifted from wagons, barges; and where it is to be dumped.

- (4) If there is any doubt as to the possibility of installing a grab due to some feature of the working conditions, a sketch of the installation giving the dimensions of any obstacles which may have to be cleared would be of considerable help.

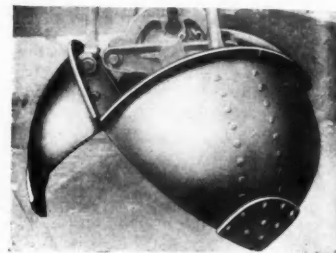


Fig. 5.

In many cases the most efficient type of grab to employ for a particular duty can best be decided by a personal inspection of the working site by a specialist. When in doubt, therefore, the grab experts should be approached for their recommendations.

Immingham Docks

Improved Coaling Facilities Planned

A scheme for lengthening the south-west arm of Immingham Dock and modernising and extending the coaling facilities to cater for increased trade is being considered by the Docks & Waterways Executive. It is estimated that by 1954 the annual total coal tonnages passing through the port will total over 5,000,000 tons, double the amount handled during 1952. The possible extension of both the south-west arm of the dock and the timber pond was envisaged when the dock was built, and the ends were left not made up with quays for this purpose.

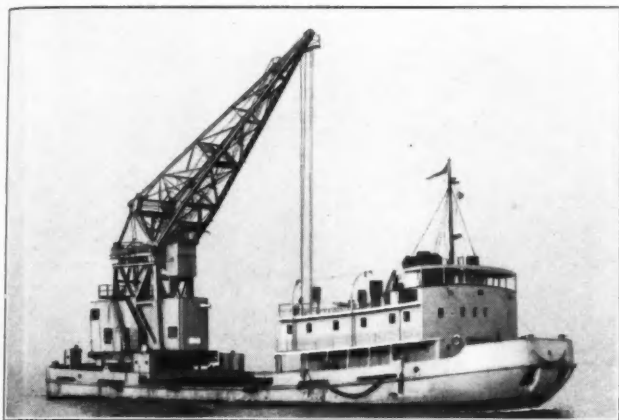
It is reported that the first step to meet the tremendous increase in the coal trade will be the replacement of some of the existing coal hoists by modern appliances, followed by the extension of the dock arm. The extension of the dock will follow these installations if present estimates for the work still hold good. It must be emphasised, however, that no sanction to proceed with any work has yet been received from the British Transport Commission; it is understood that permission for the renewal of appliances will be received in about six months. Members of the technical engineering staff of the Humber Ports have already examined modern coaling appliances in other ports and have made detailed reports on their possible suitability for the Immingham trade. The coaling appliances at Grimsby are now working a 24-hour day to cope with the increased coal trade, and there is a possibility that if it remains at its present level another hoist may be put into commission to relieve delays.

Manufacturers' Announcements

New Floating Crane for Port of Liverpool

The most recent addition to the floating craft owned by the Mersey Docks and Harbour Board is the twin-screw self-propelled 25-ton floating crane "Titan" which has been built by Messrs. Lobnitz and Co. Ltd. to replace the existing crane of the same name built over 56 years ago.

The design incorporates many novel features; after model tank tests it was decided that a spoon form of hull forward would be the most suitable and this decision was fully justified during the speed trials when the vessel comfortably exceeded the contract speed of 9.3/4 knots.



25-ton floating crane "Titan."

The hull of the "Titan" is of all welded construction with a complete main deck, raised deck forward, swim-ended stern and plated skegs for carrying the propeller shafts. Midships a large deck area has been arranged and strengthened to carry a deck cargo of 120 tons.

The hull is sub-divided into ten water tight compartments formed by three transverse and two longitudinal bulkheads, the latter being spaced about 3-ft. from the sides of the vessel and forming an inner shell.

The main dimensions of the "Titan" are:

Length overall	151-ft. 3-in.
Breadth moulded	42-ft.
Depth moulded	11-ft. 6-in.

Her working light draught including full bunkers and necessary water aboard is 7-ft. 6-in. and the loaded draught 8-ft. 8-in.

The accommodation for officers and crew is situated on the accommodation deck forward above the machinery casing, separate cabins being provided for the master, mate, two engineers, cook and boy, as well as the ship's office and the dining saloon. The crew is housed on the starboard side in two rooms, one accommodating five seamen and the other two firemen and a greaser, whilst adjacent there is a large mess room for the use of the crew.

The propelling machinery consists of two sets of open type triple expansion surface condensing steam engines each developing approx. 400 i.h.p. at around 185 r.p.m. The propellers are spaced approx. 22-ft. apart to give the craft maximum manoeuvrability when working in confined waters. Steam is supplied by two oil-fired Scotch marine type boilers working under forced draught conditions and the usual attendant auxiliaries are installed. To supply electric power for the crane two independent steam generators are fitted each having a capacity of 120 Kw.; either set being capable of providing power for the crane as well as supplying power for lighting and domestic services. As a standby when no steam is available electric power is provided by a diesel-driven generating set.

The deck machinery comprises two steam-driven anchor windlasses forward, the anchors being housed in suitable recesses in

the shell plating. At the after end an electrically-driven warping winch is installed.

The crane was constructed by Cowans, Sheldon and Co. Ltd., Carlisle, and is able to lift, slew and luff, with a maximum radius of 60-ft. and a minimum radius of 22-ft. It has a hook range of 72-ft. above water level at 60-ft. radius, with a total range of lift of 115-ft. It can luff inwards and outwards with a 25-ton load at 12-ft. per minute, and can lift a 25-ton load at a speed of 25-ft. per minute. The crane can turn a full circle in three minutes.

All the controls are arranged so they can be worked by the operator in the control box 40-ft. above the water line. About 65 tons of fixed ballast and 25 tons of travelling ballast are arranged in the crane.

Other features of the crane include a discriminator relay that automatically increases hoisting speeds for all weights less than 12½ tons, and an articulated jib head-light which follows the load when derricking. Like the board's "heavy-weight" floating crane "Mammoth" (lifting capacity 200 tons) the "Titan" is fitted with an ammeter calibrated in tons to weigh the load being lifted, and all the crane movements are braked in the event of failure of the current.

A twin-screw steam-driven floating crane with a lifting capacity of 100 tons is at present under construction for the Mersey Docks and Harbour Board at Messrs. Lobnitz and Co. Ltd.'s yard in Renfrew. This vessel is to replace the floating crane "Atlas," built in 1884 at Newcastle.

New Industrial Tractor

The new Fordson Major Tractor, already well known in the agricultural field, has been followed by a new model specially designed for commercial users. This industrial tractor was introduced at the Smithfield Show at Earls Court held recently and is intended for haulage in docks, jetties and factories, and shunting on railway sidings, to name but a few of its applications.

Diesel or petrol engines are available, the diesel engine developing 40.5 b.h.p. and the petrol engine 39.5 b.h.p. at 1,600 r.p.m. Six forward gears gives variable road speeds of from less than 1 m.p.h. to more than 14 m.p.h.; the high reverse ratio is well suited to the majority of requirements and a low ratio is provided for manoeuvring in confined spaces.



The brake drums attached directly to the rear wheels are operated by a single foot pedal, giving positive control under all conditions, whilst the multiplate hand-operated transmission brake ensures safe parking. Heavy-duty 9.00 x 36-in. six-ply industrial pneumatic tyres fitted as standard equipment give long life under the most arduous conditions; 6.00 x 19-in. pneumatic tyres are fitted to the front wheels.

Standard equipment includes a speedometer and an adjustable convex rear-view mirror. The drawbar has been designed for easy operation and to obviate "snatch" when taking up the load. Time wasted when hitching and unhitching loads is reduced to a minimum, and the new rear towing attachment combines a simple automatic hitch with a spring-loaded drawbar.

Manufacturers' Announcements—continued**New Passenger Launch**

On December 21st last, the 40-ft. "Ikeja," second of two launches built by Grimston Astor of Bideford for the Elder Dempster Lines, was handed over to the owners at Liverpool after a 250-mile trip from Bideford. The first launch "Falaba" was delivered last October. Both these craft have been designed for service as ship to shore tenders on the West African coast; the "Falaba" will operate at Freetown and the "Ikeja" at Lagos.

Built of light alloy to Ministry of Transport requirements using the "Two Way Tension" system of construction in which this company specialises, these launches are designed for carrying 16 passengers at a time, from liners to West African harbours. For this purpose they are required to combine a speed of 14 knots with good sea-keeping qualities and considerable toughness to withstand damage when riding alongside jetties and ships in the heavy swell which prevails on the West African coast.



Passenger Launch "Ikeja."

The principle of the "Two Way Tension" system has been described as follows:

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Order for Underwater Television

The first export order for British underwater television equipment calls for the supply of Marconi-Siebe, Gorman equipment to Yugoslavia. The order has been placed by the Belgrade shipping material imports company of Brodoinpeks for dock and harbour inspection work in Yugoslavia's Adriatic ports.

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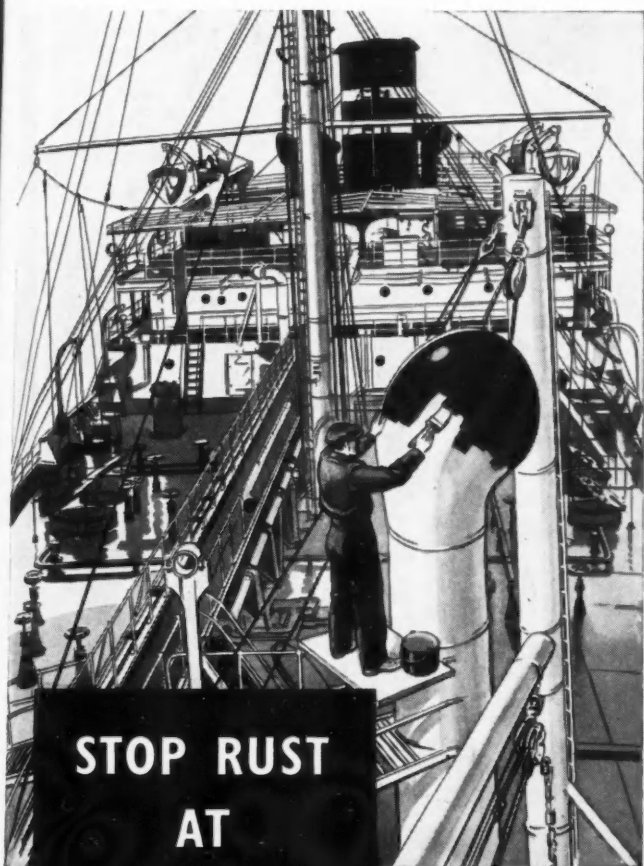
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INDEX TO ADVERTISERS

Allen, Edgar & Co., Ltd.	viii	Igranic Electric Co., Ltd.	xvii
Barclay Andrew, Sons & Co., Ltd.	xxx	Industrial Trading Corporation "Holland"	xviii
Booth, John, & Sons (Bolton) Ltd.	xxix	I.T.D., Ltd.	xxvi
Broom & Wade, Ltd.	xix	James Contracting & Shipping Co., Ltd.	vi
Butters Brothers & Co., Ltd.	xx	Kalis, K. L., Sons & Co., Ltd.	xiv
Buyers' Guide	xxxiv	Lewis and Tylor Ltd.	xxviii
Cementation Co., Ltd., The	xxx	Lobnitz & Co., Ltd.	Back Cover
Chain Developments	xxxii	Mercury Truck and Tractor Co., Ltd.	xvi
Christiani & Nielsen, Ltd.	Back Cover	National Coal Board	xxvii
Clubley Armstrong Danarm, J.	xxx	Nu-Swift, Ltd.	288
Conveyancer Fork Truck Co.	xli	Port of Bristol	xxix
Cossor Radio, Ltd.	xxiii	Priestman Brothers, Ltd.	Inside Front Cover
Cowans, Sheldon, & Co., Ltd.	Inside Front Cover	"Ronex"	xxvii
Crandall Dry Dock Engineers, Inc.	xxix	Simons, William, & Co., Ltd.	xxxi
Crossley Brothers Ltd.	xli	Small & Parkes, Ltd.	vii
Decca Radar, Ltd.	xxi	Sotramer	xl
Docks & Inland Waterways Executive	xxxii	Spencer (Melksham) Ltd.	xxiv
Douglas (Sales and Service) Ltd.	vii	Stent Precast Concrete, Ltd.	xxxiii
Dredging & Construction Co., Ltd.	xxv	Stothert & Pitt, Ltd.	iii
Ferguson Brothers, Ltd.	v	Summerson, Thos., & Sons, Ltd.	xiii
Finlay Conveyor Co., Ltd., The	x	Tilbury Contracting & Dredging Co., Ltd.	Inside Back Cover
Fleming & Ferguson Ltd.	xxxiii	Timber Development Association	xxii
Fowler, John & Co. (Leeds) Ltd.	xxxi	Under Water Sales, Ltd.	xxix
General Electric Co., Ltd., The	iv	Ward, Thos. W., Ltd.	ix
Goodyear Industrial Rubber Products	xv	Wellman Smith Owen Eng. Corporation, Ltd.	ix
Gourock Ropework Co., Ltd., The	x	Westminster Dredging Co., Ltd.	Front Cover
Harbour & General Works, Ltd.	xxx	Westwood, Joseph & Co., Ltd.	xxix
Head, Wrightson & Co., Ltd.	iv		



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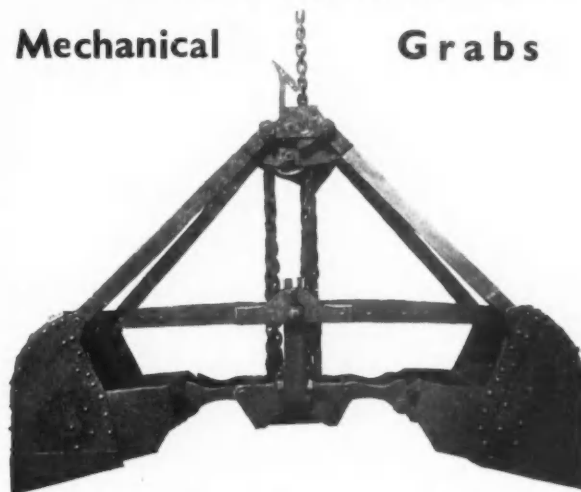
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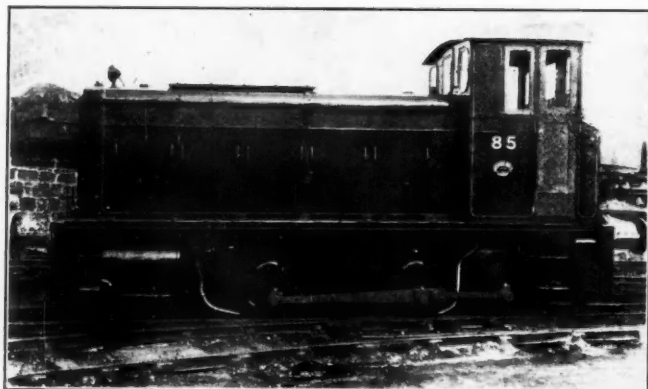
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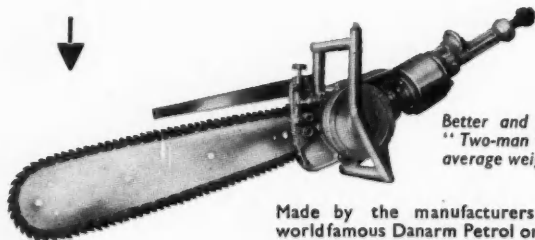
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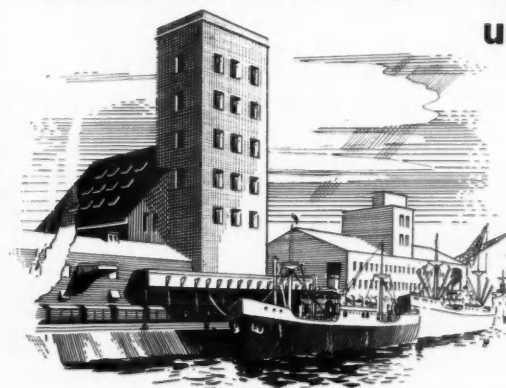
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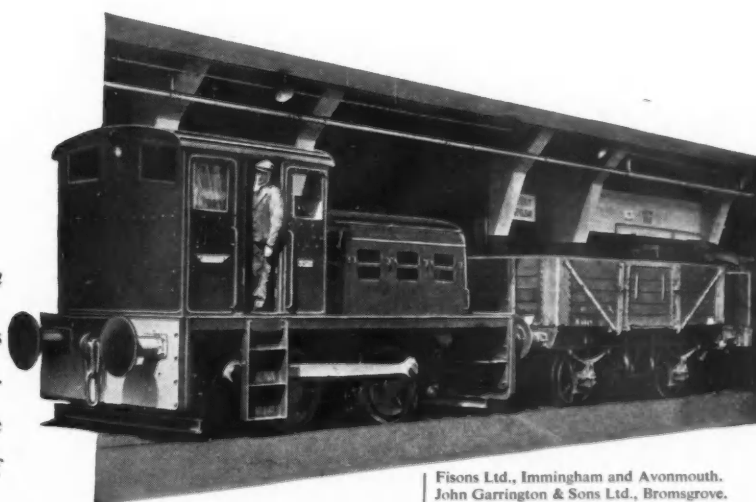
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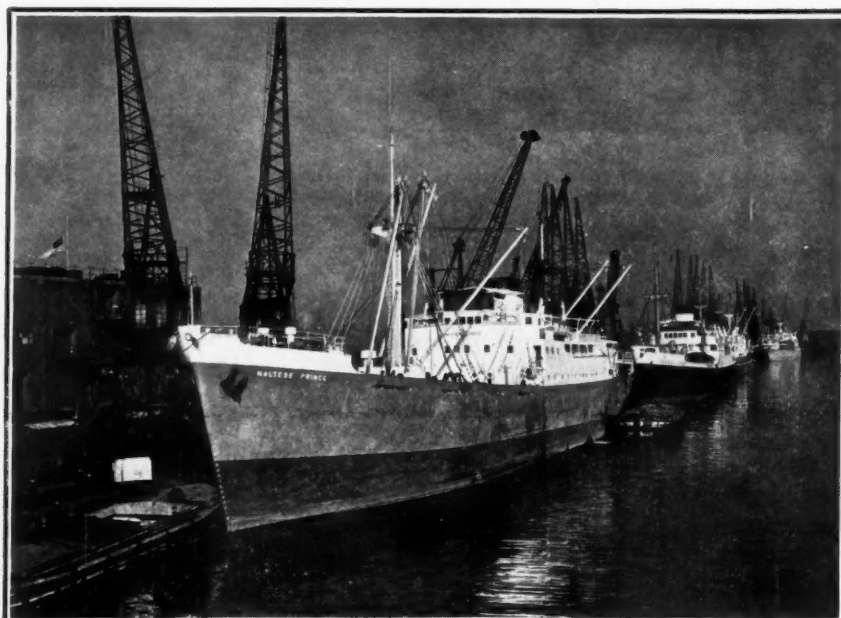
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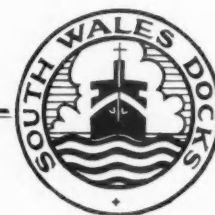


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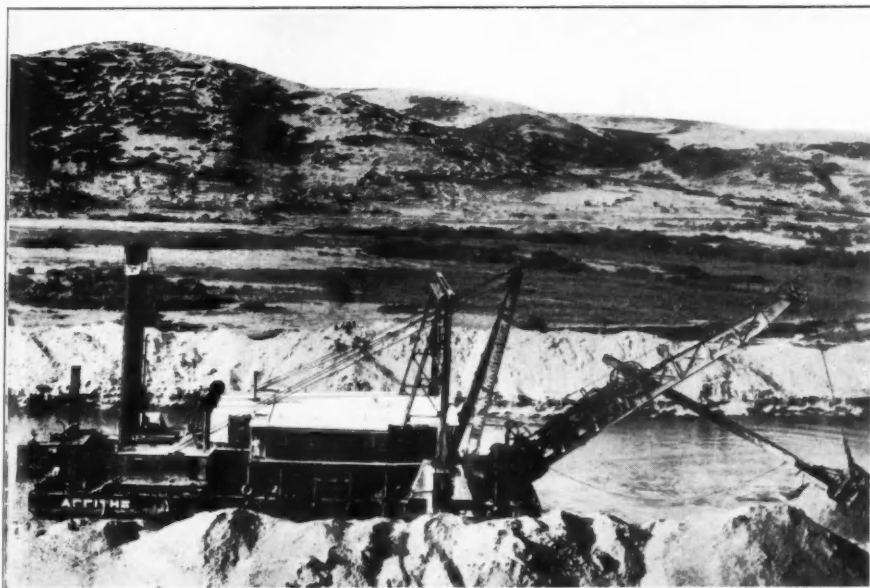
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WESTWOOD, JOSEPH, & CO., LTD., Napier Yard, Millwall, London, E.14.

GRAIN HANDLING MACHINERY.

SIMON HANDLING ENGINEERS LTD., Cheadle Heath, Stockport.
SPENCER (MELKSHAM), LTD., Melksham, Wilts.

HYDRO-SURVEYS.

KELVIN & HUGHES (MARINE), LTD., 107, Fenchurch Street, London, E.C.3.

LIFTS AND HOISTS.

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FOWLER, JOHN & CO. (LEEDS), LTD., Leeds, Yorks.
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NATIONAL COAL BOARD, BY-PRODUCTS, N.P., Bank Buildings, Docks, Cardiff.

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DORMAN LONG & CO., LTD., Middlesbrough.

POWER SAWS.

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COSSOR RADAR, LTD., Cossor House, Highbury Grove, London, N.5.
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AUTOMATIC TELEPHONE & ELECTRIC CO., LTD., Radio and Transmission Division, Strouger House, Arundel Street, London, W.C.2.
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WARD, THOS. W., LTD., Albion Works, Sheffield.

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STANDARD RAILWAY WAGON CO., LTD., Reddish, Stockport.

REINFORCED CONCRETE ENGINEERS.

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TIMBER DEVELOPMENT ASSOCIATION LTD., 21, College Hill, London, E.C.4.

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January, 1953

THE DOCK AND HARBOUR AUTHORITY



The advertisement features three black and white photographs of dredging operations. The top photograph, framed in an oval, shows a large dredger working in a harbor with a large building in the background. The middle photograph shows a dredger with a large hopper on its deck, moving material. The bottom photograph, framed in a rectangular shape, shows a dredger working near a pier with a city skyline in the background. A banner with the text "DREDGING SPECIALISTS" is draped across the middle of the advertisement. At the bottom, the company name "Tilbury Contracting & Dredging Co Ltd" is prominently displayed, followed by the address "2 Caxton Street, Westminster, London, S.W. 1." and a circular logo that reads "ESTD 1884".

DREDGING SPECIALISTS

**Tilbury Contracting
& Dredging Co Ltd**

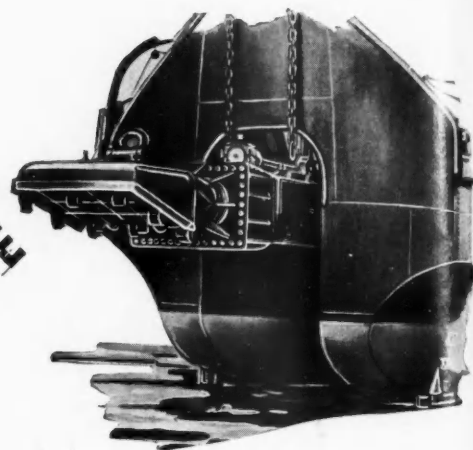
2 Caxton Street,
Westminster, London, S.W. 1.

ESTD 1884

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The illustration shows the suction mouthpiece fitted to a Lobnitz-built Suction Hopper Dredge, owned and operated by a well-known British Port Authority.

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